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The Dock & Harbour Authority

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BSP Pile Driving Equipment — used in all parts of the world

BSP pile driving equipment is designed for driving steel, timber and concrete piles for all types of civil engineering construction. In the illustration a raking plant with a 4-ton single-acting hammer, mounted on a pontoon, is driving 150-ft. pre-stressed concrete piles in the Lake Maracaibo Oilfield, Venezuela.

Contractors: C. A. Constructura Heerema, Maracaibo, Venezuela.

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TECHNICAL REPRESENTATIVES THROUGHOUT THE WORLD

World's Largest Grab Dredger

The Mersey Docks and Harbour Board have recently taken delivery of the largest grab hopper dredger in the world. Built by Messrs. Lobnitz & Co. Ltd., Renfrew, " Mersey No. 40 " is a twin-screw diesel electric grab hopper dredger having four Priestman 7-ton electric grab cranes mounted on deck amidships. The vessel is propelled by two pressure-charged uni-directional diesel engines, each developing 1,170 B.H.P. at 375 r.p.m. driving bronze propellers through scoop controlled fluid flywheels and reversing reduction gear boxes. The design to which this remarkable dredger has been built exhibits several unique features and one cannot help but be impressed by the clean layout, smooth operation and flexibility of the machinery installation.

Photograph by courtesy of Messrs. Lobnitz & Co. Ltd.

General Arrangement

The pleasing appearance of " Mersey No. 40 " is shown by our illustration. The vessel has been constructed in accordance with the requirements of Lloyds Register of Shipping for the highest classification of that Authority and the following are leading particulars of the design:

Length overall	263′ 0″
Length between perpendiculars	250′ 0″
Breadth overall	47′ 7″
Breadth moulded	46′ 0″
Depth moulded	19′ 0″
Draft light forward	3′ 2″
Draft light aft	13′ 10″
Draft loaded forward	14′ 5½″
Draft loaded aft	15′ 6″
Displacement loaded	3,675 tons
Hopper capacity	2,000 tons
Service speed loaded	12 knots
Maximum speed light	14½ knots
Engine r.p.m.	375
Crew	17

Features of the profile are a moderately raked stem of round-plate construction; cruiser stern; two-tier deck houses aft, the navigating bridge being approximately amidships. The bridge, it will be noted, is arranged at a level which affords a wide view for navigation and for the control of dredging and loading operations. The midship portion of the hull is occupied by the hopper and wing buoyancy spaces, the hopper sides being sloped inwards to allow easy flow of the spoil to the hopper doors in the bottom of the vessel. The hopper is spanned by a deep longitudinal girder which carries the door-operating mechanism.

Grid plates are fitted over the hopper to retain large stones, ropes and other bulky debris discharged by the grabs, and which might damage the doors should they find their way into the hopper, thus only comparatively reasonable size spoil has to pass through the doors during the discharging operations. The dredging cranes being placed two port and two starboard amidships, can discharge either forward or aft, thus giving a complete coverage of the hopper and enabling loading to be carried out to the required trim.

The hopper doors, six in number, are hinged at the hopper sides and are controlled by hydraulic rams, one ram for each pair of doors. The rams are capable of sustaining the full load but the cotter system is used to avoid the necessity of hydraulic pressure being applied continuously. The doors are of robust all-steel construction and being hollow they are partially buoyant, a feature which assists the retention of the dredgings. The hydraulic cylinders have been designed to withstand a working pressure of 1,000 lb. per square inch.

Dredging Cranes

The main items of the deck machinery are the four electrically-driven grab dredging cranes of the fixed jib type, having a working radius of 20-ft. All four cranes are capable of a dredging depth of 55-ft. below water and each grab has a capacity of 85 cu. ft. representing a gross load (including the grab) of 7 tons. The weight of the spoil handled per lift by each grab is approximately 4 tons. Each crane is powered by a hoisting motor capable of developing up to 99 h.p. and a slewing motor having a peak of 30 h.p.

The drivers are positioned well forward on the superstructure on raised platforms in separate compartments giving them an uninterrupted view of the work, and electric heaters are provided to ensure their comfort under winter conditions.

During trials the hopper of 2,000 tons capacity was filled in under 2 hours.

It is estimated that this new grab hopper dredger will be capable of dredging from the Liverpool Docks over ¾ million tons annually and when it is borne in mind that the spoil is deposited some 15 miles from the Docks this is no small achievement.

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Editorial Comments

The Port of Aden

When Aden is mentioned in the news these days, it is usually concerned with the political trouble that occurs in the Aden Protectorate, or with its strategic importance as a gateway to the hinterland of Arabia. However, it has other claims to importance, being an international bunkering port and also having a rapidly growing entrepôt trade. It is with these aspects that our leading article for this month is concerned. This gives an account of the history and development of Aden with particular reference to the recent port development works undertaken there.

If one considers the bay enclosed by Aden Colony as a horseshoe, at the end of one arm there is Little Aden and at the other Aden proper. It is at Little Aden that the Anglo-Iranian Oil Company constructed a refinery as well as a new harbour with tanker berths to serve the Refinery. On the other arm, at Aden itself, is the Aden Harbour which is so well known to travellers to India and the East. It is this harbour, on which the commercial interests of Aden are centred, which has recently been the scene of a development scheme and forms the subject of our article.

As the bunkering of ships has formed the mainstay and nurtured the growth of Aden, it is understandable that the layout of the harbour has been primarily developed to this end. Prior to the recent improvements, berths for ships were all at buoyed moorings, apart from a small quay at Maala, which at low water has a depth of six feet of water alongside to cater for coast-wise shipping.

The increasing demand made on the Colony for the provision of greater facilities for vessels using the harbour has necessitated the provision of fixed deep water berths. A development scheme has therefore been undertaken which both in its present form and in its capacity for future extension follows a carefully prepared plan.

Whatever may be the political outcome in the southern part of Arabia, the prosperity of Aden is bound up with the continued use and expansion of the Suez Canal to meet the need of the maritime countries trading between Europe and the East. It is to be hoped that the works now nearing completion will have a full and useful life.

New Deepwater Harbour at Portland, Victoria

On page 203 of this issue we are publishing the first instalment of a Paper by Mr. E. P. C. Hughes, O.B.E., B.Sc.(Eng.) which was recently presented to the Institution of Engineers, Australia. The paper, which many of our readers will find of considerable interest, describes the investigation and design work carried out in preparation for the construction of the new deepwater harbour at Portland, Victoria. The harbour is to be an artificial one with two breakwaters of rubble mound construction enclosing a water area of some 250 acres, suitable for the ultimate accommodation of up to eight overseas cargo vessels and two tankers, and with provision for five coastal shipping berths and accommodation for fishing and harbour craft.

The first stage now under construction provides for two overseas cargo berths and one tanker berth, with road and rail facilities and land reservations for the establishment of industries. The work of investigation included a survey of the trade potential, the examination of the marine conditions and littoral drift, the location of a quarry to supply 2,000,000 cub. yds. of rock, and borings, surveys and soundings over the whole area.

In the design of marine structures full use was made of the technique of model testing as a tool in design. Work on investigation and design was started in 1951 and preparations for construction were put in hand in 1953, with a view to completion of the first stage in 1959.

The fifth annual report of the Portland Harbour Trust issued last August states that good progress has been made to date and the work is up to schedule. The Commissioners hope to develop trade between Australia and the Far East. Condensed milk is already being shipped direct from local factories to Singapore, Penang and other Asian ports, and this is expected to be followed by exports of wheat, flour and raw salt. Proposed imports include phosphatic rock and sulphur for the manufacture of superphosphate.

Twenty-six overseas and inter-State vessels berthed at Portland during the past financial year and nearly £3 million worth of goods was exported.

Cranes for Modern Dry Docks

Elsewhere in this issue will be found an article on " Dry-dock Cranes " which is one of the series we are publishing on " Modern Dry Docks." The article is confined to the discussion of fundamental principles, and the section dealing with permissible stresses in the crane structure is based on the recommendations of a Subcommittee of the British Standards Institution. Included in this section are notes on the allowable loading on truck wheels, rollers and derricking screws. Various types of cranes are described and illustrated, and data relating to capacities and speeds are given. Those having to draft specifications will find of interest the paragraphs on effect of humidity, anchorage and control. It is noted that standardisation of high-tension three-phase power transmission does not imply that cranes must, of necessity, be driven by induction motors. For certain motions of high-capacity cranes handling valuable and widely-variable loads controlled creeping speeds are requisite, and in such cases the author favours D.C. motors, or A.C. commutator motors. High-efficiency conversion of A.C. to D.C. can be effected in a substation or on the crane.

The Proposed Dry Dock at Cork

The urgent need for new additional dry dock accommodation in Western Europe cannot be disputed and it is virtually impossible to place a limit to the extent to which this demand may grow in the next few years.

The Maritime Institute of Ireland are performing a useful service in drawing attention to the advantages of the old naval dock-yard on Haulbowline Island in Cork Harbour as a possible site for one such dock. Details of their proposals will be found on page 201 of this issue.

Cork Harbour has certain advantages which favour such development and, like every other existing site, certain disadvantages. Geographically it is in an excellent position, being in close proximity to many of the main shipping routes. A medium sized oil refinery is to be constructed there which means that fuel oil for bunkering will be available. The claims made for accessibility

Editorial Comments—continued

by 100,000 ton tankers, however, are, we feel, rather exaggerated. In the first place, entrance to the harbour in unfavourable weather is impracticable for even conventional ocean going liners, as has been shown on many occasions during recent years. There is a danger that the supporters of the project have underestimated the difficulties of handling these huge vessels in waters which are restricted in both depth and space. To handle these ships in safety calls for the use of a considerable number of tugs and the cost of providing these could not be justified by the demands of a dry dock and one medium-sized refinery.

The question of labour is also important and it should be realised that to provide constant employment by one isolated dry dock is scarcely practicable. More docks or other ship building activities would be called for and no site for even one dock in addition to that proposed appears to be available.

The foregoing criticisms must not be taken to indicate that, within its limits, Haulbowline dockyard should not be enlarged and revived. It may, however, be wiser for those interested to concentrate on much smaller vessels than those suggested by the Marine Institute in their proposals.

Finally, there appears to be some misapprehension about the projected refinery about to be built on Cork Harbour. This is a comparatively small plant designed to serve the relatively limited demand in Ireland alone. The suggestion that it might be used for a major refinery to serve countries overseas cannot be taken seriously in view of the fact that during recent years it has been found more desirable to refine oil as close as possible to the areas in which it is in demand.

Ratification of Oil Pollution Convention.

Ten countries including five with tanker fleets of not less than half a million gross tons have now ratified the International Convention for the Prevention of the Pollution of the Sea by Oil which our readers will remember was drawn up in London in 1954. This is the number required to make the Convention effective and, in accordance with Article XV, the Convention will come into force on July 26 next year.

The main effect of the agreement will be that ships registered in Convention countries will be prohibited from discharging persistent oils, such as crude oil and fuel oil, within certain sea areas. In general these sea areas extend 50 miles from any coast, but the Convention also prescribes a very extensive prohibited zone for the protection of United Kingdom coasts. British ships registered in the United Kingdom are already prohibited from discharging persistent oils in this zone, which extends far into the Atlantic.

This is a most important development in the campaign to protect the beaches from oil pollution and one that will be warmly welcomed by all those countries who supported the 1954 international conference which was convened by the U.K. Government.

The following countries have so far become parties to the Convention: Belgium, Canada, Denmark, Federal Republic of Germany, France, Mexico, Norway, Republic of Ireland, Sweden and the United Kingdom. The total deadweight of their combined fleets is 20,343,947 tons, whereas at the end of last June the world tanker fleet amounted to more than 47,000,000 tons. Among those countries which have not yet signed the Convention are the United States, Liberia, Panama, Italy, Holland and Japan.

Topical Notes

Deepening of Kiel Canal.

The depth of the Kiel Canal is to be increased to an operational figure of 11 metres and to an ultimate depth of 12 metres after further dredging during the next ten years to enable 45,000 ton tankers to pass through. This announcement was made last month at Kiel by Dr.-Ing. Chr. Seebohm, Federal Minister of Transport, who pointed out that a greater depth would be uneconomic as it would involve the reconstruction of locks and all bridges.

Television Harbour Aid at Singapore

The Singapore Harbour Board is now experimenting with a closed-circuit television system covering the Empire Dock which will enable the wharf superintendent to maintain better control over the movement of vessels. Singapore is believed to be the first port in the world to install this facility. If the experiment is successful, there is no doubt that the system will increase the safety of vessels leaving the dock, as well as of those proceeding to or from their berths on the outside wharves.

Proposed Quay Extension at Freetown

It has recently been announced that the Government of Sierra Leone have given authority to commission consultants to take borings and submit designs for a proposed extension to the Queen Elizabeth II Quay at Freetown, which was opened in May 1954. At present, only two large ships can be accommodated at the quay and it is now planned to extend the jetty by 300-ft., bringing the total length of the quay to 1,500-ft. This extension will be the first stage in a development plan which in later stages will include the provision of bunkering, general cargo and mineral loading berths.

Progress of Construction Works for the Delta Plan.

The Dutch Ministry for Transport and Waterways has announced that work on the construction of the Zandkreek dyke, which is to connect the islands of Walcheren, North Beveland and South Beveland, will be commenced early in 1958. This will be the first dyke to be built in accordance with the Delta Plan, details of which were published in our issue for April, 1954.

Work is nearing completion in the Haringvliet on the enclosure for the huge sluices which will form part of the enclosing dyke and on completion of this work, which is expected to be early next year, the actual building of the sluices will begin. The working harbour near Vrouwenpolder in Veergat is now in use and the construction of the barrier in the Hollandse IJssel is making steady progress although, as the engineers have not been able to carry out the full programme scheduled for 1957, it will not be completed by this December.

Also in the Haringvliet during 1958 a dam is to be built east of Flakkee and on the other bank, a working harbour is planned near Willemstad. Preparatory work will be commenced on the Grevelingen dam.

Dredging Improvements at Fao, Iraq.

The Iraqi Ports Administration has stated that, as a result of a new dredging programme commenced at the end of last year, progress is being made in deepening the entrance channel to the Shatt-al-Arab and in providing more adequate turning room for deep-draught vessels using Fao Harbour. The following navigable depths in the dredged channels have been declared: Outer Bar Reach 26½-ft.; Inner Bar Reach 26-ft.; and Foa Reach 26½-ft.

With these depths in the channels and corresponding improvements in the Fao turning basin, the Administration will be able to accept vessels of up to 34-ft. draught in view of the fact that at high water the depths of the dredged channels rise by 10-ft. Until further dredging at the oil jetties has been undertaken, however, completion of loading to 34-ft. will still have to be effected on the rising tide before departure. At No. 4 jetty, improvement to a depth alongside of 36-ft. at low water is almost completed.

Carriage by Sea of Liquid Natural Gas

According to the annual report of the Gas Council for the year ended March 31st last published early this month, some of the technical problems involved in the shipment of liquified natural gases appear well on the way to solution. Engineers of the North Thames Gas Board have made several visits to the United States for the purpose of obtaining data for the design of a ship to carry refrigerated methane and the Ministry of Transport, the Home Office, Port of London Authority and Lloyd's Register of Shipping have been kept in touch with all developments.

Readers will recall that brief details concerning the transport of natural gas appeared in the September 1956 issue of this Journal. The liquefaction of methane reduces its volume to 1-600th of that which it occupies as gas, but to do this the temperature of the gas has to be reduced to – 161.5 deg. C., and the liquid must be kept at that temperature during transport.

It is expected that a trial shipment of liquid natural gas will be brought to the Thames within the next eighteen months.

The Port of Aden

Description of Recent Development Works

(Specially Contributed)

DURING the past few years a development programme has been under way in Aden. The programme has included dredging to maintain the harbour at the advertised depths, the dredging of new deep berths and channels, the construction of a new Import Quay with transit sheds, and the provision of new lighter berths. The new quays are designed to handle the entrepôt trade of Aden which has been developing steadily in recent years.

The dredged spoil has been used to reclaim land at Steamer Point, Maala and elsewhere and the reclamation, forming an integral part of the development scheme with the construction of the Import Quay and Lighter Cut Wharves, has changed the character of the Aden waterfront.

The background to this development programme and some of the design and constructional details involved are described in this article.

History.

The southern part of the Colony of Aden comprises a rocky peninsula and a hilly headland jutting out from the southern coast of Arabia. The Bay, which lies between the peninsula and the headland, forms the fine deep water harbour which exists to-day.

The port has had a chequered history through the centuries. It was captured by the Romans, who knew it as Arabia Feh. At the beginning of the 16th Century it passed to the Portuguese, who were in turn expelled by the Turks in 1538. It then came under the suzerainty of the Sultan of Senna until, in 1750, the Sheik of Lahej became the ruler of Aden. It was captured by the British in 1839.

The original anchorage was on the south side of the peninsula at Hokat Bay which afforded easier access to the trading community than the inlet on the north where the present harbour is situated. With the advent of steam navigation, coaling became an important consideration, and between 1850 and 1880 many grants were made for the construction of coal wharves on the foreshore of the present inner harbour, where better facilities existed than at Hokat Bay.

The Aden Port Trust was formed in 1889 and its first operation to develop the port was the dredging of the inner harbour to secure depths of 25 to 26-ft. over an area of some 163 acres and the provision of six berths. The work was carried out in three stages of 20, 24 and 26-ft. and was completed in 1901.

From 1901 until 1908 several schemes were proposed for the further dredging and extension of the Port, including the provision of public wharves. Very little was accomplished until 1908 when a dredging contract was let which was completed in 1910, as a result of which the minimum depth in the inner harbour was increased to 30-ft. and two berths were dredged giving depths of 33 and 34-ft.

The next dredging programme was commenced in 1928 and completed in 1930. The mooring basin was widened on its northern side and extended inwards and the whole area and the approach channel dredged with the object of obtaining a depth of 33-ft. below Low Water Indian Spring Tides. In addition two areas, each 1,600-ft. by 400-ft. were dredged to 35-ft. for deep draught ships.

Early in 1941 the Admiralty carried out extensive dredging operations, designed to extend the existing deep water area, and this work was completed in 1944. With this further extension and deepening, Aden Harbour, as it existed before the present development, had a dog leg approach channel just over two miles in length with a width of 600-ft. dredged to 36-ft. at L.W.I.S.T. The main portion of the inner harbour, which extends to 287 acres, had been dredged to the same depth. Immediately to the east an area of 74 acres had been dredged to 27-ft., and still further east approximately 73 acres dredged to 18-ft. The harbour is protected to a considerable extent from the S.W. Monsoon swell by a breakwater, extending in a north westerly direction from Ras Morbut. To the north of the harbour there is a long rubble mound; both were constructed during the years 1939-45.

A survey, carried out from 1949 to 1950, showed that although the dredging completed by the Admiralty was patchy and irregular, with the result that a very uneven bottom was obtained, no great siltation has taken place and that there was no immediate need for maintenance dredging. The amount of siltation was approximately at the rate of 2-in. per year

Trade.

Aden became of great importance with the opening of the Suez Canal and the East/West sea route on which it became a firmly established coaling station. With the change from coal to oil Aden has become a great oil bunkering port and to-day is among the leading ports of the world in shipping tonnage entering and leaving the harbour. The figures for bunker oil imported and for coaling are shown in the following Table.

Table 1. Imports of Oil and Coal

	Bunker Oil *Tons*	*Coal* *Tons*
1946—1947	837,012	348,542
1947—1948	1,045,044	265,613
1948—1949	1,637,463	177,758
1949—1950	2,291,267	257,623
1950—1951	2,657,166	99,468
1951—1952	2,182,994	127,443
1952—1953	2,749,695	22,817

In addition to catering for inter-continental traffic, Aden is the centre for a considerable coastal trade in the Red Sea and Persian Gulf areas, whilst many of the exports of Ethiopia and Somalia (Somaliland) find their way to Aden before being shipped to more distant ports. Table 2, on the following page, shows the important items of import and export trade for the years 1949 to 1953.

Excluding the business in oil for bunkering, total imports amount to approximately 512,000 tons and exports to about 445,000 tons; included in these figures are about 184,000 tons of imports and 127,000 tons of exports in general mixed cargoes which are handled mainly at Maala.

Future Developments.

Before 1950 the development of the port was very largely a question of dredging to increase the deep water area and depth, in order to meet a steadily increasing demand for the accommodation of shipping at buoyed moorings. When planning for the future, however, the Port of Aden had to be considered not only as a transit port but also as a terminal port with a lively entrepôt trade with the hinterland of Arabia. This entailed an extensive development scheme, a part of which has now been completed.

Suez Canal.

By reason of its position on the Red Sea trade route, which has made it a great fuelling port, the prosperity of Aden is bound up in the prosperity of the Suez Canal. It has always been the policy of the Port Trust to keep abreast of the progressive stages in the development of the Canal and to be in a position to accommodate any vessel that can negotiate the Red Sea route.

Matters Relevant to a Plan of Development.

The foregoing historical details coupled with the trade figures show that a development plan must have two main objectives.

Firstly, the maintenance of the harbour and its mooring facilities to cope with the ever increasing demands made by shipping. Secondly, improvement in facilities for handling commercial traffic.

The Port of Aden—continued

Table 2. Extract from the Administration Reports of Aden Port Trust for 1949-53

Important Items from the Import and Export Trades

IMPORTS Particulars of Principal Items	1949	1950	1951	1952	1953
Animals (No.)	130,601	104,997	115,211	175,598	172,552
Apparel and Haberdashery (value EAS)	6,467,462	12,864,984	17,096,930	14,485,411	17,924,184
Coal and Coke (tons)	230,991	110,545	124,546	69,815	44,032
Coffee (tons)	11,364	7,314	7,465	7,218	10,878
Cotton Twist and Yarn (tons)	2,488	4,728	3,416	1,959	1,949
Cotton Piece Goods (yards)	101,117,982	107,543,783	123,431,669	124,836,125	90,315,339
Grain, Pulse and Flour (tons)	52,452	54,376	54,132	58,798	62,458
Gums and Resins (tons)	1,815	2,102	2,824	3,210	2,203
Hides, raw (No.)	81,160	160,680	208,980	102,040	286,200
Liquors (gallons)	212,611	175,956	269,536	258,325	646,704
Metals (tons)	6,806	7,789	3,194	14,669	61,801
Oil, Kerosene (gallons)	1,439,754	1,262,480	1,674,784	1,362,304	1,962,117
Dates (tons)	6,967	10,139	14,568	14,388	13,494
Ghee (tons)	321	211	441	117	157
Salt (tons)	—	—	—	—	—
Seeds (tons)	1,584	1,715	1,620	1,613	16,256
Shells, Mother of Pearl (tons)	220	202	199	3,013	173
Silk Piece Goods (yards)	—	—	—	—	—
Skins, raw (No.)	5,013,620	4,723,400	4,083,407	3,188,220	5,852,340
Spices (tons)	3,010	3,309	1,903	2,196	2,570
Sugar (tons)	17,462	15,942	16,371	10,399	157,534
Tobacco (tons)	2,974	3,244	2,937	2,075	3,594
Wood (value EAS)	2,047,329	3,400,518	3,974,802	6,634,845	18,822,793

EXPORTS Particulars of Principal Items	1949	1950	1951	1952	1953
Animals (No.)	24,407	6,733	17,689	60,108	28,791
Apparel and Haberdashery (value EAS)	1,467,084	2,936,477	1,128,248	323,066	3,517,806
Coal and Coke (tons)	—	—	—	—	—
Coffee (tons)	8,593	7,070	7,752	8,853	8,256
Cotton Twist and Yarn (tons)	1,981	4,122	3,532	1,981	2,220
Cotton Piece Goods (yards)	67,447,187	84,419,267	99,975,789	91,836,056	80,296,752
Grain, Pulse and Flour (tons)	46,961	34,212	40,523	38,090	35,322
Gums and Resins (tons)	1,759	1,933	1,985	2,044	2,058
Hides, raw (No.)	156,220	252,820	332,860	287,445	212,911
Liquors (gallons)	—	—	—	—	—
Metals (tons)	3,627	3,794	6,167	2,567	3,708
Oil, Kerosene (gallons)	368,210	246,643	243,154	80,690	153,754
Dates (tons)	4,221	6,027	9,499	9,379	8,692
Ghee (tons)	283	267	178	192	316
Salt (tons)	228,048	235,516	338,757	342,196	165,638
Seeds (tons)	935	524	3,596	4,207	4,409
Shells, Mother of Pearl (tons)	234	179	121	85	104
Silk Piece Goods (yards)	81,056	375,580	412,291	34,920	90,149
Skins, raw (No.)	5,495,520	7,372,160	4,931,160	2,042,380	4,929,417
Spices (tons)	1,996	1,274	1,207	13,420	1,429
Sugar (tons)	10,627	9,173	8,505	30,040	5,951
Tobacco (tons)	1,344	1,298	998	977	1,563
Wood (value EAS)	239,729	327,954	267,531	295,778	242,109

This improvement should be such as to attract trade and must therefore be in advance of demand so that the facilities are there when required.

The first of these objectives can be dealt with by a programme of dredging designed to maintain the existing berths in the harbour at the advertised depths, to increase the area of such depths and to improve the arrangement of mooring and bunkering so that not only can a greater number of ships be accommodated but the time they spend in harbour can be reduced to a minimum.

The second of these objectives calls for an approach along two lines. One is designed to increase the capacity of the public wharves under the control and operation of the Port Trust and the other to encourage private enterprise to exploit and expand the capacity of Aden to act as an entrepôt port.

It was realised that these objectives were complementary to each other and that the use of dredged material in reclaiming valuable land would enable a trading estate to be built and also provide land for other industrial and commercial uses.

The Plan of Development.

A development programme was therefore prepared under the following headings:—

(1) Dredging and reclamation;
(2) A revision of moorings;
(3) A construction programme timed to fit in with the reclamation programme and to provide: (a) Additional public wharves of increased capacity, and (b) Private wharves for commercial use but under the control of the Port Trust.

The opportunity was taken to plan the development so that it would be capable of logical expansion in the future. A conservancy line was proposed and a policy in respect of future waterside development outlined for many years to come.

The first part of the development plan is now nearing completion.

Programme of Works.

The dredging programme consisted of:—

Maintenance Dredging.

(1) Dredging the entrance channel and inner harbour to a minimum depth of 37-ft. below L.W.I.S.T. The advertised depths are quoted at 36-ft. so that, allowing for siltation at the rate of 2-in. per year, it is not anticipated that any maintenance dredging will have to be carried out for some years.

New Dredging.

(2a) An area on the northern side of the entrance bellmouth was dredged to a depth of 37-ft.

(2b) Forming four new berths; three of 40-ft. (advertised 39-ft.) in the 36-ft. area of the inner harbour and one of 37-ft. (advertised 36-ft.) in the existing 33-ft. area of the inner harbour.

(2c) Deepening the existing 27-ft. area of the inner harbour to 30-ft.

This dredging enabled ships of greater draft to enter the harbour and also permitted the largest ships to berth without restriction on entry and departure. In addition, dredging was carried out to

The Port of Aden—continued

provide the new channels and basins required as part of the plan to provide increased wharf facilities. These comprised:

(1) For the Import Quay: An entrance channel with a minimum depth of 18-ft. below L.W.I.S.T. leading to a basin of 20-ft. depth, adjoining which was a basin of 9-ft. depth.

(2) For the Lighter Wharves: A channel, known as the Lighter Cut, with a depth of 9-ft. below L.W.I.S.T. These areas are shown in Fig. 1.

Dredging Operations.

Dredging was carried out by a bucket dredger capable of dredging to a depth of 66-ft. and of lifting 700 cubic yards of free material in one hour. The dredged spoil was discharged into hopper barges alongside the dredger, which were then towed to the reclaimer unit positioned opposite the area being reclaimed. Four hopper barges and two tugs of 300 and 330 B.H.P. were used. The dredged spoil in the barge was slurried by the addition of water under pressure and then pumped ashore through 24-in. diameter pipes. The maximum length of pipe from the pumping plant to the discharge point was 2,500-ft. which included the floating part of the pipeline. The reclaimer unit was capable of pumping 5,000 tons per hour at 25 per cent. solid material by volume, with free discharge. A bifurcation in the pipe with control valves enabled continuous pumping to be carried on while changes were made in the lengths of discharge pipes and the place of their discharge. Fig. 2 shows a general view of the finished reclamation.

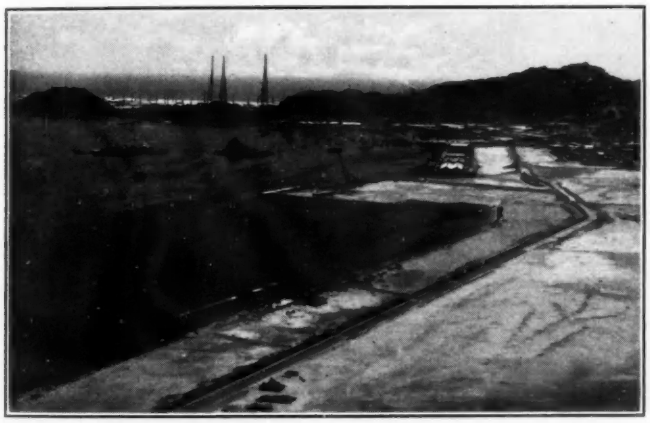


Fig. 2. General view of finished Reclamation. Lighter Cut Wharves under construction in foreground and Import Quay under construction in centre.

The whole of the dredged spoil, which amounted to 3,389,000 cu. yds., was used in reclaiming areas behind the new quays as well as forming five new areas elsewhere. The total area reclaimed amounted to 190 acres.

These areas are shown in Fig. 1 which also shows the constructional works included in the present development programme.

Construction Works.

The programme of construction was arranged to accord with the dredging programme and, in sequence of operations, consisted of:

(1) The formation of rubble bunds to retain dredged spoil. In these were incorporated bunds which were used for the plant for building the quay walls.

(2) The building of the Import Quay extension and the return wall to the existing Maala Wharf.

(3) The building of two lengths of quay wall for berthing lighters.

(4) The construction of roads, pavings, sheds and ancillary works.

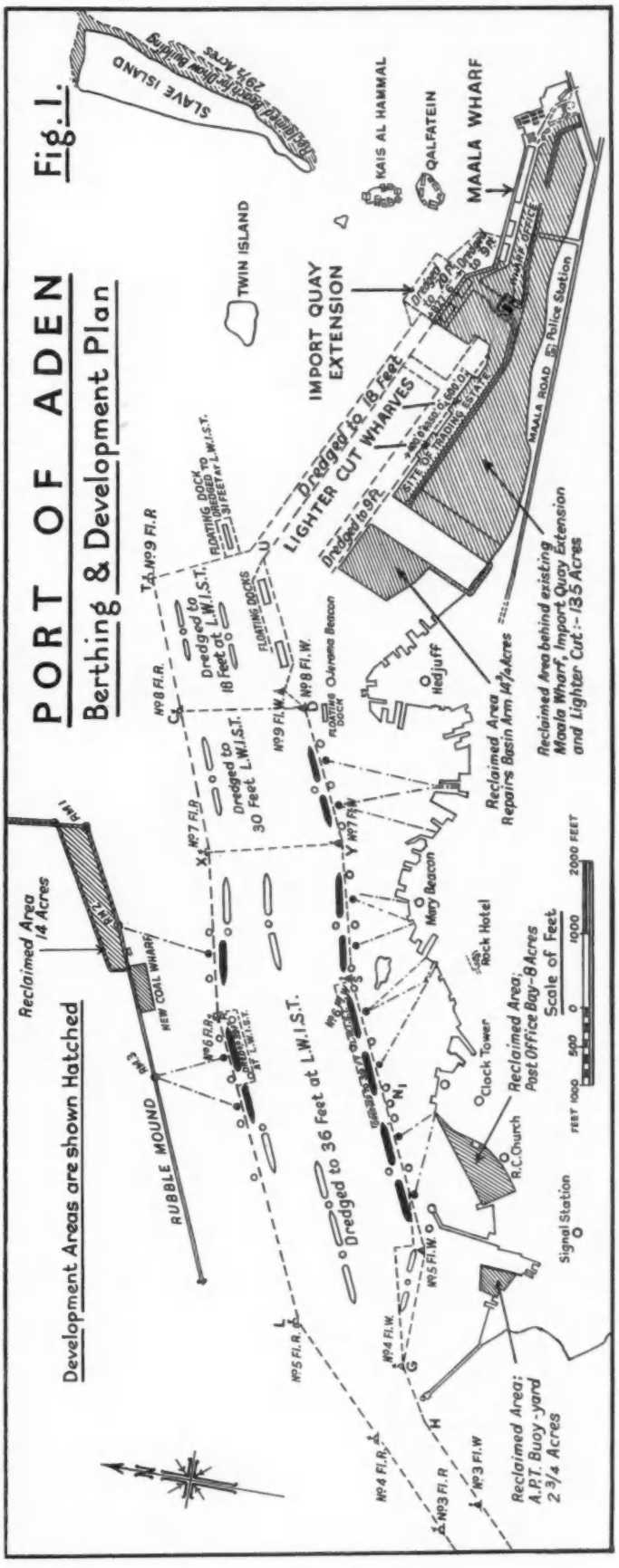
Rubble Bunds.

The rubble for the bunds was obtained from the scree on the slopes of the hills overlooking Maala, more than half a million cu. yds. of rock being required for this purpose. The bunds are protected on the seaward face by a stone toe, with the greater part of the individual stones ranging in weight from 1½ to 3 cwts., and the face is pitched with stones ranging in weight from 60 to 100

Fig. 1.

PORT OF ADEN

Berthing & Development Plan



The Port of Aden—*continued*

lbs. each. In exposed places the weight of individual stones in the toe is up to one ton.

The inside face of the bunds was blinded or sealed to prevent seepage and loss of the reclaimed material. Openings were left in the bunds to allow the surplus water, used in pumping the dredged spoil ashore, to escape.

Import Quay Wall.

The wall is 827-ft. long and has a minimum depth of water alongside of 20-ft. The overall height is 37-ft. 6-in.

Piles were driven through this fill to support the crane gantry columns and this phase of the work, showing the concreting of the pile caps is shown in Fig. 5.

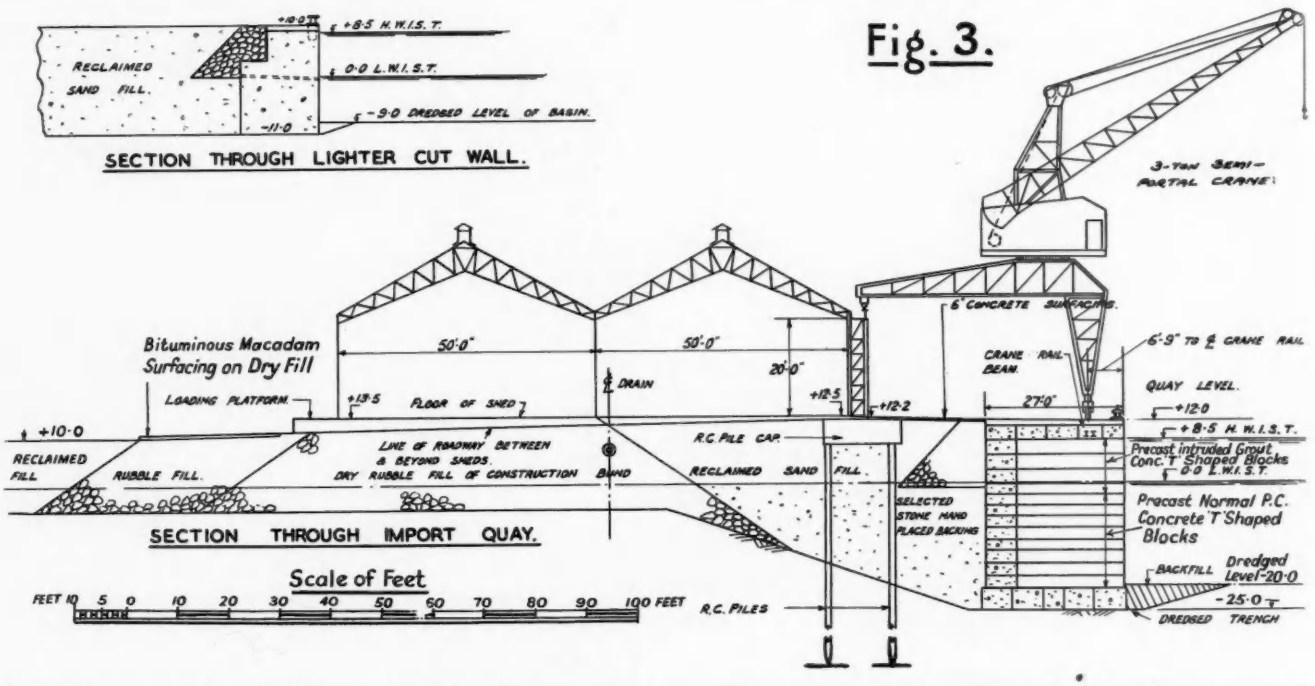
Fig. 6 shows a view of the nearly completed wall with the wharf sheds and gantry steelwork partly erected.

Lighter Cut Quay Walls and Return Wall of Import Quay.

These walls, which are only slightly more than half the height of the Import Quay Wall, are constructed in mass concrete.

The Return Wall which connects the Import Quay Extension to

Fig. 3.



Tee blocks were used in the design of the wall. These are mass concrete blocks shaped in the form of a tee, the head of which forms the back of the wall. This form of construction concentrates the weight of the wall towards the heel so that, with the added load from the retained ground, the resultant pressure is uniformly distributed on the foundation below the base.

The result is a considerable saving in cost and a most economical design of wall combined with the advantages of low maintenance costs inherent in mass concrete construction.

Concrete blocks span between the tees to form the deck and are covered with a 12-in. thick paving slab. Bollards are set along the front of the quay and Goodyear tubular rubber fenders, suspended on chains, are provided. A typical section through the wall is given in Fig. 3. The volume of concrete involved was approximately 20,000 cu. yds. in a total of just over 2,000 blocks and both normal Portland cement concrete and intruded grout concrete were used.

Aggregates in Aden leave much to be desired and considerable research was undertaken to make the best use of those available. Intruded grout concrete, which was used for blocks above a level of 2-ft. below L.W.I.S.T., was improved by the addition of fly ash to give added resistance to the concrete in the part of the wall subject to attack by wind and tide. The use of the intruded grout process allowed the use of the fine sand from the Sheikh Othman deposits near Aden, as well as the larger, uniform sizes of stone aggregate.

The blockwork was placed by a derrick travelling on rails on a bund behind the wall on the site occupied later by the sheds. Fig. 4 shows the derrick on the construction bund and the partly completed wall. The area between the wall and the construction bund was filled with approximately 60,000 cu. yds. of reclaimed sand which had been stockpiled previously on the reclamation areas by the dredging contractor.

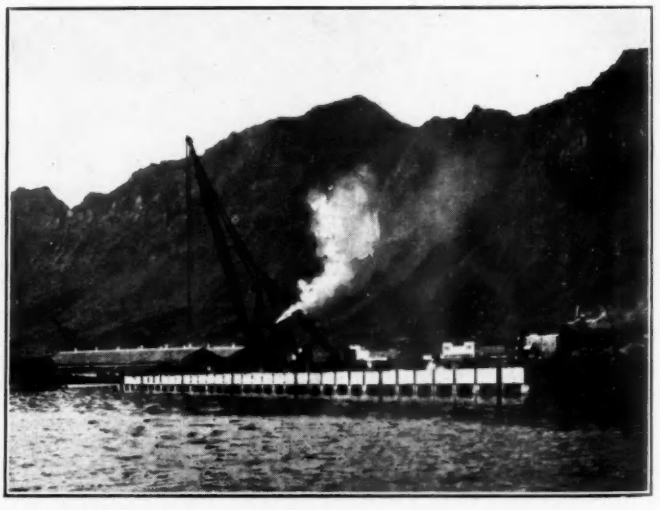


Fig. 4. View of Import Quay under construction.

the Maala Wharf is 360-ft. long and has a width of paving on top of 50-ft. backed by a 40-ft. wide roadway. Boat steps and ladders are incorporated in the quay face. The fendering consists of Goodyear tubular fenders set diagonally on the face of the wall. The top of one fender overlaps the bottom of the next so that all parts of the face of the quay receive protection.

The Lighter Cut quays are limited in the present stage to two lengths, one of 400-ft. and the other of 600-ft. separated by a gap 350-ft. in length (Fig. 7). These walls were built on a rubble

Port of Aden—continued

foundation placed in a trench excavated previously by the dredging contractor. Steel shutters in the form of boxes 36-ft. long by 15-ft. wide by 14-ft. high were set on the foundation and filled with concrete by the intruded grout process. These boxes were set to form "hit" bays and the intervening "miss" bay concreted in a following operation. With intruded grout concrete the rate at which the aggregate was grouted was in excess of 10 cu. yds. per hour, which enabled very good progress to be made.

The line of the face of the walls is 80-ft. in front of the seaward edge of the bund retaining the reclamation, so that future extension can be carried out on the same line.

A typical section through the wall is shown in Fig. 3.

Fig. 5. Import Quay wall showing paving work in progress and concreting of pile caps in foundations to crane gantry and sheds.

Roads, Pavings, Sheds and Ancillary Works.

The outline form of the development works is shown in Fig. 1. Auxiliary works included roads, paved areas, drainage, sheds, wharf cranes, water supply, fire fighting arrangements, electrical supply and lighting.

The reclaimed area at Maala is divided by a road and a boundary wall running East-West about 300-ft. from the faces of the new Lighter Quays and the Maala Wharf. Entrance to the new Import Quay is by a wide concourse where a new Wharf Office will be built. Beyond the entrance a 30-ton weighbridge and two smaller weighbridges will be installed.

In the Port Trust area another East-West road serves the Trading Estate area in the rear of the Lighter Cut Wharves. It is this area that the development scheme looks to private enterprise to develop. Plots will be leased by the Port Trust to concerns and traders participating in the import-export industry or otherwise requiring ready access to the harbour.

Sheds. The import quay constitutes the public wharf. It is served by two transit sheds each 250-ft. long by 100-ft. wide and three 3-ton semi-portal cranes. The sheds have tubular steel trusses supported on rolled steel joist columns.

Wall cladding is corrugated galvanised iron and roof cladding is in asbestos cement sheets. Doors on double tracks allow direct access from the quay to any part of the sheds. The gantry carrying the rear legs of the cranes is incorporated in the special double columns of the front of the sheds and on steel A-frames between and beyond the sheds. The seaward legs of the cranes are supported on bogies running on a rail track incorporated in the quay.

The distance from the face of the quay to the sheds is 50-ft., and the use of semi-portal cranes allows an uninterrupted width of quay of over 40-ft.

The area behind the Import Quay for a distance of 180-ft. from the face of the quay, including the sheds, is paved. Levels are arranged to provide for loading platforms along the length of the landward side of the sheds.

Provision of sheds on the Trading Estate is carried out by the Port Trust in co-operation with the lease-holders.

Drainage. In spite of the low average annual rainfall experienced in Aden provision of surface water drainage has been made and a system of open drains, running alongside the roads and paved areas, discharge into culverts outfalling in the sea.

The lines of the culverts have been so arranged that little interference will be caused to future development of the Trading Estate.

Water Supply and Firefighting Arrangements. The provision of fresh water to ships is a service required of most port authorities. This service is carried out in Aden by water barges carrying the supply to the mooring berths.

With the provision of alongside berths for coastal vessels now established, this service will be provided by a mains system drawn from the mains supply of the Colony. Ten hydrant points on the front of the quays (eight on the Import Quay and two on the Return Wall) have been installed backed by a main 4-in. in diameter. Water is delivered at these hydrant points through removable, metered standpipes capable of discharging and metering at a rate of up to 100 tons per hour, which fit on to a standard hydrant, set in a pit on the quay. The pits are covered by hinged cast iron covers so that when the hydrants are not in use the surface of the quay is level and unobstructed.

In addition to the fresh water there is a separate main with hydrants for the supply of water for fire fighting purposes. This main can be fed either from the fresh water main or, in the event of this latter source failing, by a pump drawing its supply from the sea. Motorised valves, used in conjunction with the fire drill adopted for starting the sea water pumps, effectively isolate the fire main from the fresh water main. The isolating valves are not reopened until the fire main has been emptied of sea-water and sterilised.

Fig. 6. Import Quay. West Seaward Shed and Apron from east, showing nearly completed wall and shed and gantry steelwork under erection.

Wharf Offices.—The Wharf Office will be a steel-framed building, clad in the multi-coloured and pleasantly textured local stone, relieved occasionally by rendered areas.

The front entrance, which faces east, gives access to a large Main Hall where public business will be transacted. On the north and south of the Main Hall the offices of the Deputy Wharf Superintendent and the Assistant Wharf Superintendent with the various manifest and registry sections, will be located. To the west are the archives and the staff rooms. All these rooms are isolated from the Main Hall by a wide corridor to permit natural through ventilation of the building.

The Wharf Superintendent's office and adjoining Waiting Room are planned on a mezzanine floor which is partly cantilevered over

Port of Aden—continued

the main entrance and gives clear views to the north, south and east. In the west wall of the Wharf Superintendent's office a large observation window will allow supervision of activities in the Main Hall below. Here clerestory windows have been provided on three sides to give adequate natural lighting without glare.

Access has been provided to the flat roof for the observation of shipping.

Electrical Supply and Lighting. Electrical services are being provided which consist of the extension of the existing electrical distribution network in order to give a supply to the wharf cranes, lighting of sheds and wharves, fire pump and alarm system. Provision is also being made for services to the Wharf Office, gate cabins, road lighting and Trading Estate.

This will involve the change over from 6,600 volts to 11,000 volts, including the provision of new substations.

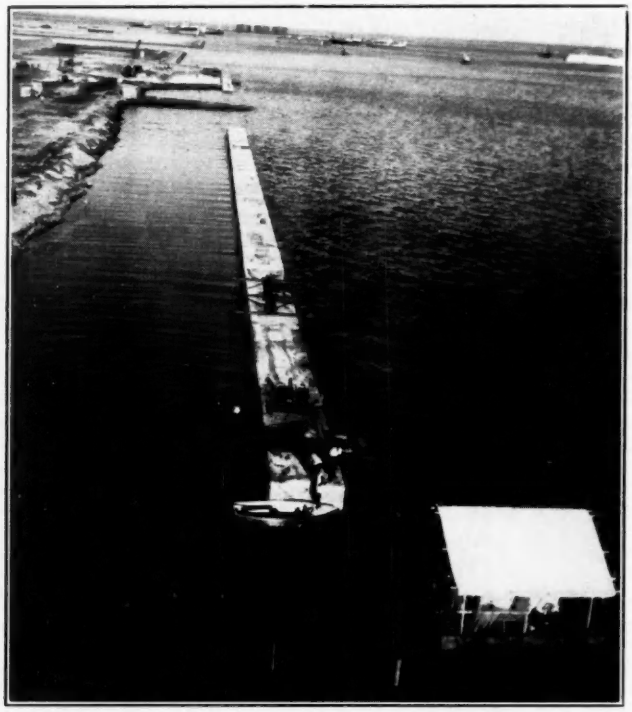


Fig. 7. View of 600-ft. and 400-ft. lengths of Lighter Cut Wharves during construction.

Estimated Cost of Works.

The development works described are estimated to cost £3,200,000. Sir Bruce White, Wolfe Barry and Partners are the Consulting Engineers and Agents and were responsible for developing the project and for the design and supervision of the Works.

The Joint Contractors for the dredging and reclamation contract were K. L. Kalis, Sons and Co. Ltd., of London, and the Dredging and Construction Co. Ltd., of King's Lynn. The main Contractor for the Civil Engineering Works was Pauling and Co. Ltd., of London, and for the installation of the water supply and surface water drainage, The Consolidated Contractors Corporation Ltd., of Aden. The materials for this latter Contract were purchased in the U.K. and shipped to Aden on behalf of the Port Trust. Suppliers of this equipment were the Stanton Ironworks Co. Ltd., of Nottingham, Glenfield and Kennedy Ltd., of Kilmarnock, Read and Campbell—London (fire fighting equipment), Leeds Meter Co. Ltd., of Leeds and Guest and Chrimes of Rotherham.

The wharf cranes are being supplied under a separate contract arranged by the Consulting Engineers with Stothert and Pitt Ltd., of Bath. In addition to the three 3-ton semi-portal cranes mentioned above four 1½-ton Coles mobile cranes are being purchased from Steels Engineering Co. Ltd., for use on the wharves.

The Transit Sheds are modified "Arcon" structures supplied by Taylor Woodrow (Building Exports) Ltd., the fabrication of special steelwork being undertaken by S. W. Farmer and Son Ltd., of Lewisham. Gates for the Boundary Wall were supplied by A. and J. Main and Co. Ltd., of Glasgow. John Booth and Sons (Bolton) Ltd., fabricated the steelwork of the Wharf Office.

Proposed Development of Haulbowline Dry Dock, Cork

Plan to Utilise Former Naval Dockyard

There has been submitted to the Eire Minister for Commerce and industry by the Maritime Institute of Ireland, a memorandum on the construction of a dry dock, estimated to cost three million pounds, at Haulbowline Island in Cork Harbour. The proposals contained in the memorandum envisage the development of the existing dry dock and ship repair basin at Haulbowline Island to a size great enough to accommodate the giant tankers now under construction and are the result of an extensive survey carried out recently by the Maritime Institute.

The memorandum begins by reviewing the trend towards greater tonnages in shipping, especially tankers, and speaks of the general concern at the lack of suitable dry dock and repair facilities. It states: "The demand for the greater docks, and anxiety to ensure that they are provided is reflected in the plans and policy of all the principal European Ports, who are currently engaged in overhauling their facilities in an endeavour to keep pace with the new shipping trends.

"There are only five commercial dry docks in the world capable of accommodating a 100,000 ton tanker, and only one of these is within easy access from the South and Eastern Atlantic. This is the King George V Dry Dock at Southampton which is in almost constant use.

"Although giant tankers are the greatest problem at the moment there is no doubt that giant passenger liners and even ore and grain carriers are going to be an ever increasing feature of the Atlantic trade in particular, in coming years. The shipbuilding orders at the present time for giant liners for the American—European trade in themselves indicate that the number of large craft on the Atlantic trade will be trebled in the next four to five years.

"While dry dock facilities at present can cater for these ships, their capacity to continue to do so is extremely doubtful. It is certain that the increasing demand on large dry dock facilities occasioned by the giant passenger liners will render the situation regarding tankers even more acute. This is especially serious in the European Eastern Atlantic areas in consequence of the vast quantity of oil and passage of tankers to and from Europe itself."

Reference is made to the increasing volume of traffic in the oil trade. "The transport of oil by sea rose from 70,000,000 metric tons in 1929 to 315,000,000 metric tons in 1954, almost a five-fold increase. The rate of consumption has doubled in the past ten years and is expected to double itself again in the coming decade." The report quotes Messrs. John I. Jacobs, of London, tanker owners, as stating that "a safe minimum figure of tankers under construction and on order is 25,000,000 tons deadweight, representing approximately 57 per cent. of the world tanker fleet existing at the close of 1956."

Under the heading "Investment Rate" the report states: "It is doubtful if the various Oil Companies, many of whom operate their own vessels, or independent owners would permit the cost of providing dry docks even for themselves, to be a deterrent to their continued development or a danger to efficient functioning. It is axiomatic that tremendous profit, and the production and distribution of oil go hand in hand. It is estimated that the oil industry is investing annually a total of about £2,900,000,000, and is expected to increase this between now and 1956 to £4,000,000,000. Even this astronomical figure is further forecast to increase by more than another 50 per cent. between 1966 and 1975 to a total of £6,500,000,000.

Proposed Development of Haulbowline Dry Dock, Cork— continued

"By these standards the investment of £12,000,000 for the refinery in Cork is a minor expenditure, and if the most vital link of all in the industry i.e., its tanker transport requires finalising in any respect, especially repair and maintenance, then there is no doubt that the requisite sums would be readily forthcoming."

The report carries on: "Having surveyed all aspects of the shipping trend which is reflected in the giant tankers, and having advanced not only the explanation which has caused the present position, but measured future development, an examination of Ireland's position and ability to provide some of the services which are in demand is of vital interest

"This country enjoys a unique geographical advantage in its relation to both the Atlantic Ocean and the trade route between Europe and the rest of the world. In addition to this geographical position the country has been favoured with many natural harbours, of which Cork is perhaps the most outstanding, not only in Ireland, but on the whole of the European Continent. It is undoubtedly true that this (together with the fact that this port can provide a depth of water which is not excelled by any port in Europe, and is only equalled by two), influenced the Oil Companies to erect a refinery there. Apart from any other factor Cork can become a vast refining, storing and distributing centre to feed Europe's growing demand for oil. The ability of the Port to cope with very large tankers. and the much shorter voyage which these would have to undertake to discharge their cargoes at Cork for refining and re-distribution, is undoubtedly a factor which the Oil Companies would consider if brought sufficiently to their attention. Any additional advantage or attraction which can be offered would also be a deciding factor.

"In this latter regard and in relation to the international dearth of Docks capable of accommodating the types of ships which are developing, Cork can offer, on the Island of Haulbowline, dry dock facilities which, with very little modification by comparison to building a new Dock elsewhere, would be the largest of its kind anywhere in the world.

"In addition to the Dock itself the depth of water in the Navigation Channel approach would more than suffice for the largest vessels afloat at the present time. It is also true that at any stage of the tide, even low water, vessels could be docked or undocked from the Haulbowline Dry Dock. This has an advantage in so far as that there are at least four clear periods in any 24 hours when there is no tidal movement or currents which would interfere with the manoeuvring of even the largest vessels.

"The Haulbowline Dock with its combined outer basin, can provide an overall length of 1,300-ft., which is considerably in excess of even the largest Dry Docks available elsewhere. It will be noted for example that the Dock would be 100-ft. longer than even the King George V Dry Dock in Southampton which is 1,200-ft. long, and is designed to accommodate the giant Cunarders "Queen Elizabeth" and "Queen Mary." As already pointed out this Dock is also the only commercial dry dock in Europe capable of accommodating a 100.000 ton tanker.

"In addition to the length, the width of the dock can be enlarged without difficulty to literally any degree required. The Dock, which is built on reclaimed land, is surrounded by a type of soil which is easily excavatable, and the area available would more than suffice to provide a beam width if necessary of up to 300-ft., which would be double the largest width of any other Dry Dock in the world.

Figure 1 has been drawn to demonstrate the geographical relationship of Cork Harbour to the Atlantic Ocean, and also illustrates the easy accessibility for tankers to the Haulbowline Dry Dock, subsequent to discharging their cargo at the Refinery approximately 2½ miles away.

"The Lock Gates (caissons) which seal off the internal Dry Dock itself, are transferable to the outer entrance for the purpose of permitting the total area of dry dock and basin to be pumped dry. This in fact was practised in the past. In the event of the dry dock itself being widened to the extent which is suggested in the shaded area on the Eastern side of the dry dock (see sketch, Figure 2) it would of course be necessary to widen the outer entrance to an identical extent. This would provide means by which vessels could be docked in either the inner portion alone if they were small, or the combined inner and outer areas for those of greater length.

Repair Arrangements.

"One of the peculiarities of tanker repair and maintenance, is the system whereby the tank portions of the ship are separated from the other sections, Bow, Engineroom, and Centre-Castle Bridge sections. This is for the purposes of replacing the tanks, which have been weakened by corrosion. The dual arrangement of Dry Dock and Outer Basin as separate entities is an advantage towards facilitating this process.

"The Dry Dock section could be utilised to house the standing sections of the ship, during the period that the replacement tank portions are either being built, or brought into position. The exceptional width of the basin portion of the present dock, 500-ft., makes manoeuvring of the separate portions of a tanker ship extremely simple.

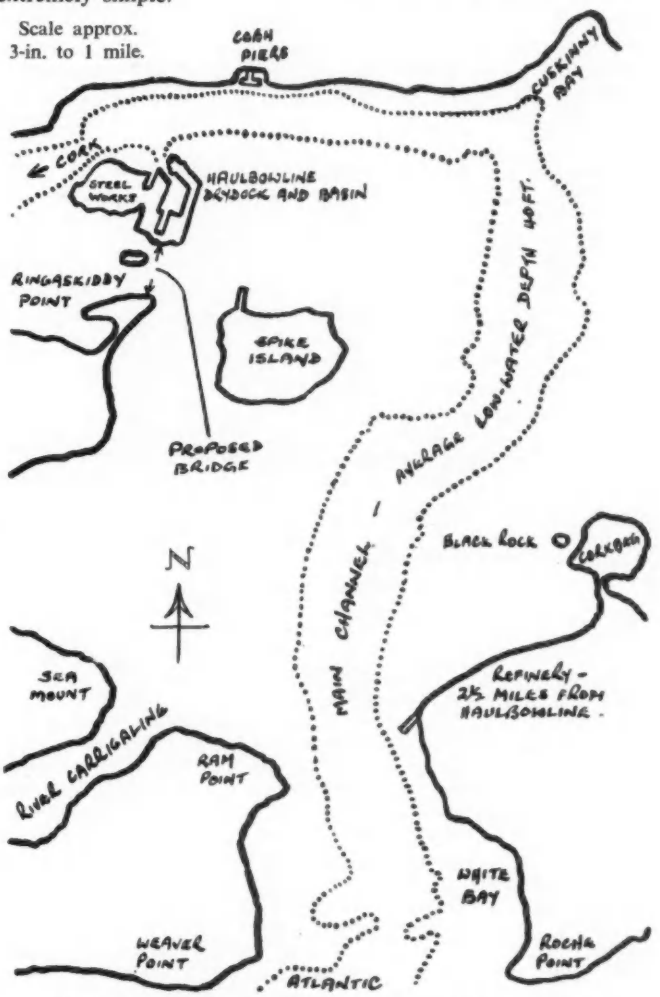


Fig. 1. Sketch showing Harbour entrance to Haulbowline.

"In addition to the geographical situation of the Dry Dock, its adequate depth of water, and exceptional overall length and width, there is a great deal of advantage to recommend it further as a tanker repair depot. It is usual in all tanker work to keep the repair yards, and all other berths as far removed from populated areas as possible. In this respect Haulbowline is ideally situated in the centre of Cork Harbour.

Bridge to Mainland.

"Its isolation however, is not a disadvantage as far as efficient functioning is concerned. Not only has it operated successfully in the past, although isolated, but for several years now large numbers of workers and quantities of materials have been brought to

Proposed Development of Haulbowline Dry Dock, Cork—continued

and from the Island to service the Steel Works which operate there. Should it be desirable however to extend the communications or enhance them in any way it would be a simple matter to build a pier or overhead bridge from the South side of the Dry Dock area of Haulbowline, to Rocky Island and Ringaskiddy Point. This proposed bridge was, in fact, recommended as a desirable development to the continued functioning of Haulbowline as a ship repair centre, as far back as 1922.

Expenditure Involved and Employment Content.

" Although it is difficult to state with any certainty the approximate cost which would be involved in converting the Haulbowline Dock into a fully up to date repair yard, the total sum should not exceed £3,000,000. This would include the restoration of the repair facilities, as well as alterations to the Dock itself. When it is realised, as already pointed out, that an entirely new and comparatively large Dry Dock has been constructed in Dublin for a million and a quarter pounds, this estimate would appear to be an outside figure. Should the Oil Companies or Tanker Operators interest themselves in this project, the expenditure required by

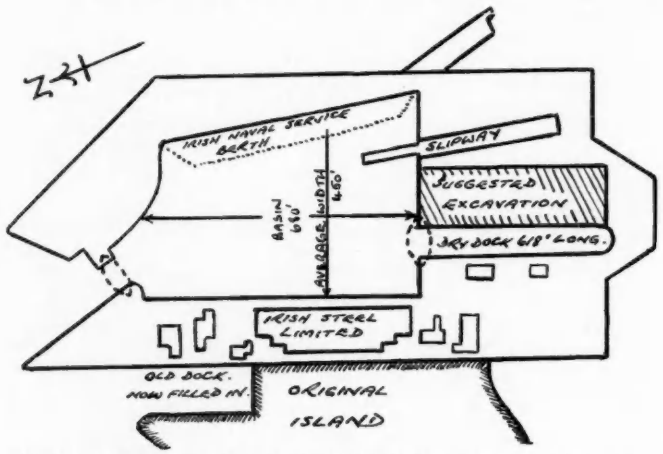


Fig. 2. Haulbowline Dry Dock, Outer Basin and surrounding area.

relation to the annual investment of these Companies, would be negligible.

" Apart from any profit which could accrue to any Interest which concerns itself with the operation of this Dry Dock, the amount of employment which it would provide would be of a very high order indeed. It is certain that in the light of the exceptional number of tankers now being built, and the very high degree of repair and maintenance which these ships require that they would provide substantial employment. In full operation the employment which would result from this type of ship repair should not be less than 500 men.

" As far as the availability of trained labour is concerned, it can be pointed out that ship repair work has been carried on for a considerable number of years now in the Cork area, and many trained personnel in excess of those who would be employed by the present Yard at Rushbrooke are available. It is certain that a very large number of trained workers could be brought back from British Shipyards where they are at present employed, and many Belfast workers highly trained in ship repair and building would be available.

" While considering the question of the availability of sufficient skilled labour, it would perhaps be opportune to point out that it is expected a large group of suitable workers in Dundalk, will be displaced as a result of forthcoming measures to curtail G.N.R. services. The responsible Minister stated recently that he was concerned with the question of finding employment for the various skills and trades engaged in the railway maintenance and repair shops in Dundalk. We would suggest that there is a sufficient number of skilled tradesmen engaged in this area and Industry, to form at least the hard core of trained personnel for a Ship Repair Centre such as we propose in Haulbowline.

" It is true that certain initial and even serious difficulties would have to be overcome if the Haulbowline Dock was to be fully employed for the purpose we suggest. It is conceded that a thorny question arises with regard to Irish Steel Limited, whose Plant at present occupies a large portion of the area that would be required if Haulbowline were to be utilised as a large active Ship Repairing Dry Dock. It is not suggested that there is any simple answer to this problem, but if this industry and its various plant can be catered for in any other part of the Island, the importance of the project would justify this. Should it not prove possible it would be conceded by all concerned that the existence of the Steel Works on the mainland would render it a much more economic and efficient industry, than in its present isolated situation. As this would have advantages for both the Dry Dock and the Steel Industry some suitable arrangement is not impossible."

Improvement Works at South African Harbours

Details were recently announced by the South African Railways and Harbours Administration of new construction works at the Ports of Durban and Walvis Bay.

Durban Improvements. The construction of two sheds at " L " and " M " berths on the T-jetty at an estimated cost of £1,122,250, including the cost of the wharf cranes, will soon be started. The shed at " L " berth will be built at the landward end of the jetty and will consist of a single storey cargo shed with a floor space of 600-ft. by 120-ft. It will be connected with " M " shed at first floor level by means of a shipping gallery which will facilitate the shipping of fruit from both " L " and " M " berths.

The shed at " M " berth will be a three-storey brickfaced building to be built on the outer end of the jetty. The ground floor with a floorspace of 900-ft. by 160-ft. will consist of an airlock and an engine room with space for cargo stacking. The first floor will be 900-ft. by 150-ft., a quarter of which will accommodate a staff mess, change rooms, various offices and cargo space. The balance will consist of pre-cooling chambers capable of handling approximately 3,000 tons of fruit. This floor has been so designed that the capacity of the pre-cooling chambers can be doubled at a later stage. The second floor will be 800-ft. by 128-ft., part of which will be used for fruit re-packing. The remainder will be used for handling passenger traffic and will incorporate the latest designs based on the terminal at Southampton. It will be provided with refreshment rooms, customs offices and examination and search rooms, retiring rooms and offices for shipping companies, the Publicity Department and the Port Captain and administrative staff. This project will be completed in about two years' time.

Ship repair facilities will be moved from the T-jetty to the Bay Head where 77 acres have been reclaimed. The work on this project will consist of the construction of a 700-ft. long double faced jetty, deepening of the S.A.A.F. basin and approaches to a depth of 28-ft. below L.W.O.S.T. and construction of a dolphin berth along the south eastern arm of the basin at a total estimated cost of £250,000.

Further major works in the harbour area include the replacement of the existing wood and iron sheds at " D " and " E " berths with a single shed of 760-ft. by 120-ft. of the latest steel frame design with brick panels at an estimated cost of £216,000. At Maydon Wharf the 2,000-ft. long timber constructed wharfs at berths 1, 2 and 4 are being rebuilt with steel sheet piling in units of 500-ft., to give a depth of 32-ft. 6-in. below L.W.O.S.T. at an estimated cost of £400,000.

Walvis Bay. Tenders from the Union of South Africa and from overseas have been invited for the works to be undertaken. The intention is to extend the existing quay of 1,500-ft. by 1,300-ft. to a length of 2,800-ft. and by so doing to provide berthage for an additional two large vessels. Approximately 200-ft. of quay will become available for smaller vessels.

The new quay will be provided with a cargo shed (400-ft. by 100-ft.), one 15-ton and nine 4-ton cranes, one storage bin for ores with a capacity of 18,000 tons, two mechanical shovels and 100 tipping buckets. It is expected that the work will be completed towards the end of 1960.

The Investigation and Design for Portland Harbour, Victoria

By E. P. C. HUGHES, O.B.E., B.Sc.(Eng.)*
(Chief Engineer, Portland Harbour Trust)

THE 500 miles of coastline between Melbourne and Adelaide is an inhospitable one for shipping, and the anchorage at the western end of Portland Bay presents one of the few points on this coast where ships may approach the land in safety in other than the finest weather.

Portland anchorage is some 200 miles from Port Phillip and 300 miles from Adelaide, and provides shelter from the prevailing south-westerly winds and seas behind the group of rocky headlands of Capes Bridgewater, Nelson and Grant (Fig. 1). The anchorage is, however, open to the south-east, and storms from that quarter, together with south-westerly swells refracted around the headlands, make the deepwater anchorage uncomfortable at times, and prevent the operations of ships at the open sea pier for several weeks in the year.

Portland is located only 40 miles from the South Australian border and is backed by a potentially rich but little developed area of agricultural and pastoral land with an assured rainfall varying from 33-in. on the coast to 20-in. in the Wimmera, 150 miles inland.

The construction of a deep sea port at Portland as a measure in the development of the State is backed by the Victorian Government, and is looked upon as providing the focus for the development of the western part of Victoria and the adjacent lands in the south-east of South Australia.

Historical.

The Town of Portland boasts of being the first white settlement in what is now Victoria, but in the first part of the 19th century was part of New South Wales.

From the days of the earliest settlement by the Henty family the anchorage has been used for shipping, and a succession of open-sea piers culminating in the present 3,000-ft. long Ocean Pier assisted by lighterage have provided the means for handling the trade of the port.

The town and port progressed rapidly in the first years of settlement, as imports of livestock and manufactured goods were brought in to open up the new territory, and the produce of the land came down with the bullock teams and was loaded for export. An early landscape painting shows that most of the important buildings of the town were built before 1850.

Later, with the rapid growth of Melbourne, the development of Portland and its district became arrested. The port suffered by comparison with Melbourne, due to lack of sheltered water and lack of a fresh water river where wooden hulls might be safely protected from marine growth and borers.

With the advent of the railways and the policy of centralisation of trade on the capital, a further check on the port was effected and for the past 50 years, in spite of spasmodic revivals in trade and efforts to improve the facilities, Portland has thrived mainly as a favoured holiday resort for the people of its hinterland.

The first recorded scheme for development of Portland as a sheltered port was that of Mr. John Barrow in 1854. Mr. Barrow was an engineer of the New South Wales Public Works Department, and he considered first the possibility of dredging a sheltered basin from the swamps adjacent to the foreshore, but decided against this on account of first cost and subsequent maintenance, and

*This paper originated in the Melbourne Division of The Institution of Engineers, Australia, and is reproduced by kind permission.

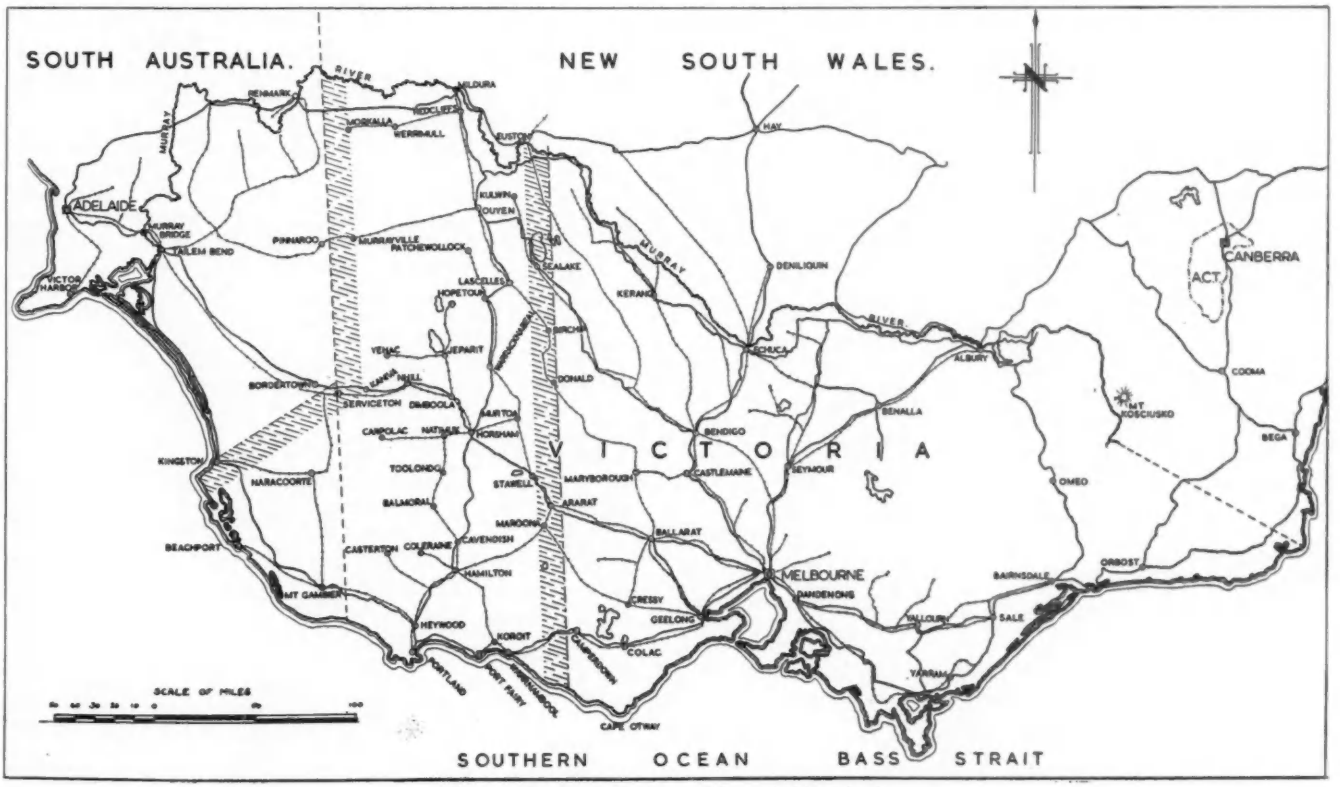


Fig. 1. Portland Harbour—Map of Hinterland.

The Investigation and Design for Portland Harbour, Victoria—continued

recommended a scheme for an artificial harbour with breakwaters on similar lines to the present scheme His proposals were never taken up and the next recorded scheme was put forward in 1879 by Sir John Coode who proposed quite a small harbour with only 18-ft of water but with provision for an outer haven, of very much larger dimensions than the present scheme, to be built later. This scheme also was not supported, and alternative proposals for open-sea piers successively extended and widened were put in hand together with a small island breakwater to provide shelter for the fishing fleet.

In 1912, Mr. E. M. de Burgh, Chief Engineer for Harbours, New South Wales, put up a scheme for a harbour very similar in shape and arrangement to that at Port Kembla which was also his design, and work on this proposal was actually started in 1913 but was suspended and finally dropped following the outbreak of war in 1914.

It was now becoming increasingly apparent that the development of the western part of Victoria and the adjacent territory in South Australia was being neglected due to the distance of these parts from the capital cities, and the consequent surcharge imposed by freight charges for all goods entering the area and produce leaving for export. It was obviously more economical to open up and develop fully, areas nearer to Melbourne than to clear and populate the remote parts of the State.

A State Parliamentary Public Works Committee took evidence on the question in 1945 and, in their report of May in that year, recommended that plans for the development of a deep-water port at Portland should be drawn up as soon as practicable so that a feasible scheme could be implemented in the early post-war period, and in 1947 the State Government invited Messrs. Rendel, Palmer and Tritton, of Westminster, London, to put up a scheme for the new Portland Harbour. The scheme put forward by this firm forms the basis of that which has been adopted for the new harbour now under construction (Fig. 2).

In 1950 the State Government appointed three Commissioners to form the Portland Harbour Trust and, in the Act promulgated in 1951, enjoined the new Commissioners to proceed with development of the port and with the encouragement of trade in and out of the hinterland. The new Commissioners proceeded energetically with their task and were able to put their plans and estimates before the State Government in February, 1951, and took over control of the port and started with the raising of funds and recruitment of staff in April of the same year, and commenced with preliminary contruction work at the end of 1952.

Existing Facilities.

The facilities of the port in 1951 consisted of a rail-served deep-water pier (Ocean Pier) 3,000-ft. long, in some disrepair but having one remaining useful berth capable of accommodating a vessel drawing up to 28-ft. of water, and a small breakwater giving shelter for a few fishing craft (Fig. 2). A second pier previously used for coastal shipping was beyond useful repair.

The berth on the Ocean Pier was in regular use for cargo vessels and also for tankers which discharged into a pipe-line laid down by the Shell Company and connected to the Shell and Vacuum Oil installations a mile inland. However, the berth was not a popular one with ships' masters, because of the surging of ships alongside in the ocean swell, and because of the risk of sudden steep seas arising from south-easterly storms. The Ocean Pier is a timber structure with piles of local stringybark, and the maintenance of piles and superstructure in a continuous and expensive task.

The Scope of Investigation and Design.

The study of conditions governing the design and construction of the new port was first undertaken by the State Public Works Department in 1948 with a thorough marine survey of the Portland anchorage and adjacent waters and by the sinking of boreholes in the bed of the sea to prove the foundation conditions for marine structures. The Portland Harbour Trust's own staff took over in

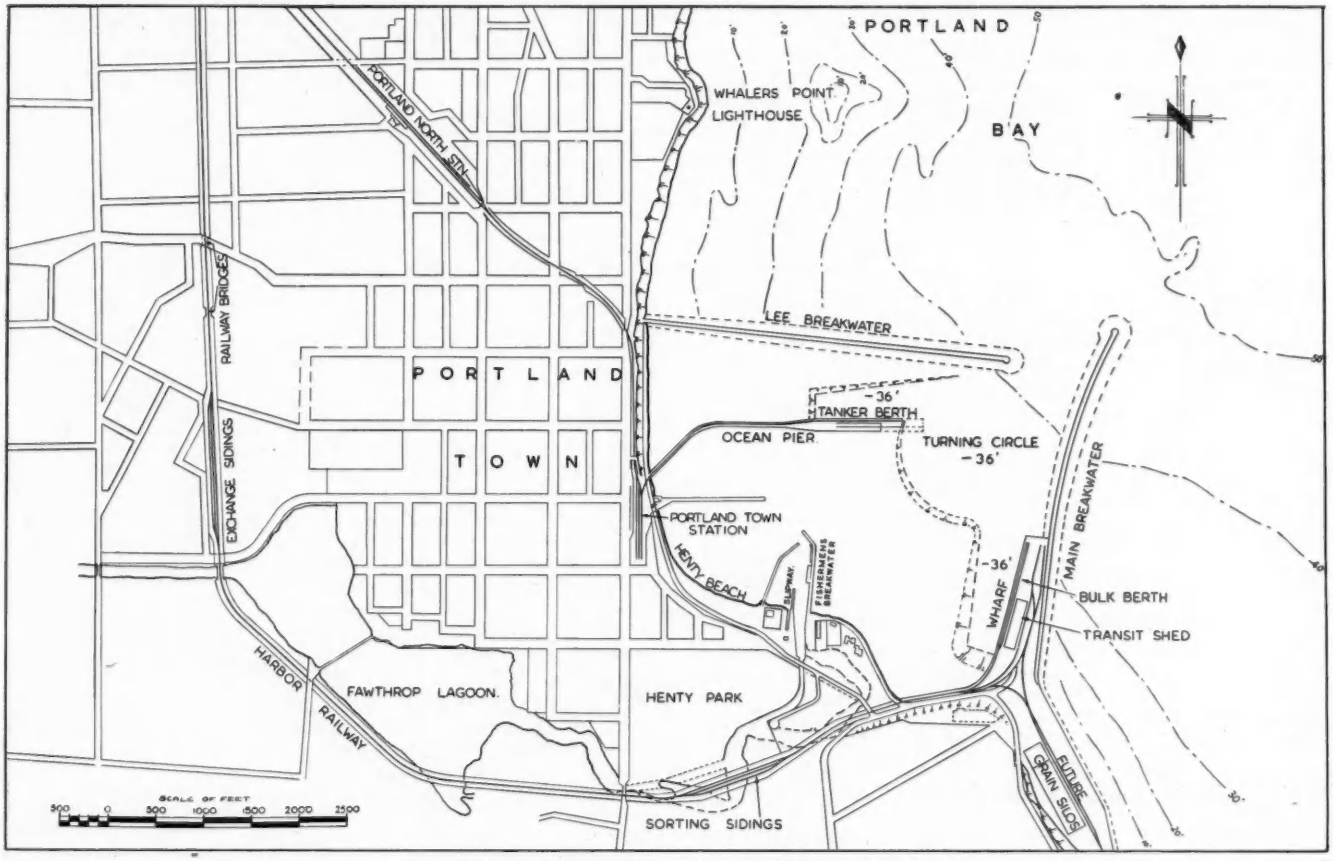


Fig 2. Stage 1 Development Plan for Completion in 1959.

The Investigation and Design for Portland Harbour, Victoria—continued

1951 and proceeded to an examination of the following principal conditions :

1. The trade requirements and potential for the new Port.
2. Topographical surveys of land and sea.
3. Wind and wave observations.
4. Littoral drift and the possibilities of sand accretion.
5. Foundation conditions.
6. Quarry sites.
7. Sources of concreting sand and aggregate.

Simultaneously, the preliminaries of design were gone into, including a study of the latest trends of harbour and wharf layout from similarly situated ports elsewhere in the world.

The technique of model testing for marine structures was also developed, and much assistance in this regard came from the New South Wales Department of Public Works who were carrying out their tests on the model of Port Kembla Harbour at the time, and from United States authorities whose advice was fully and freely given.

Trade Requirements and Potential.

Before considering the layout of the new harbour it was necessary to decide on the space and draft factors which should be taken into account, and on the number and extent of berths and other facilities which should be allowed for. It was felt that the forecasting of these factors could not be an exact matter and would have to be done by broad comparisons with similar conditions elsewhere, and by taking into account the trend of population increase and its effect on the hinterland in the next 50 years.

It was assumed for the purpose of this investigation that the hinterland of Portland would ultimately include all districts which were closer to Portland by rail and road than to Geelong in the east and Adelaide in the west. The area thus defined was found to have a population of about 250,000, almost entirely an agricultural and pastoral community inhabiting some 25,000 square miles of country, much of which was only developed to a fraction of its potential.

The rate of population growth in this area was approximately 3 per cent. per annum, which it was assumed would continue for the next 50 years, giving a population of approximately half a million in 1980 and over a million at the end of the century.

The exports from the area were wool, dairy produce, fruit, meat, hides, tallow and grain, and the imports were fertilisers, petroleum products and manufactured goods generally. Potential exports were softwoods and softwood products and hardwood. The geological report was that there were a few minerals in payable quantities in the area.

The population and trade figures were analysed and were compared with established similarly situated hinterlands elsewhere, both in Australia and overseas, notably in New Zealand and in South Africa. From these studies it was decided that a port capable of handling import and export cargoes up to 1½ million tons deadweight (or, say, 3 million shipping tons) per year should satisfy requirements for the next 50 years.

As regards water depths, the present trend both here and overseas is to provide for 36-ft. at deep-sea berths, allowing for ships drawing up to 33-ft. at all states of the tide. With the present limiting depth of the Suez Canal of 36-ft. this is only likely to be reached with occasional ships. However, it was recognised that all ships' dimensions are increasing to provide for greater speed, and the least dimension of a ship is still its draft. It is thought likely that naval architects will seize every opportunity in the future to increase the draft of ships, and it was considered prudent to make allowance for deepening the turning circle and at least some of the berths in the future to 40-ft. below low water.

The port would have to be road- and rail-served and with storage accommodation off the wharves of equivalent capacity to the transit shed and dump accommodation at the wharf side, so that transit sheds and areas could be cleared completely between shiploads.

In addition to nearby storage facilities, it was considered necessary to locate and reserve factory sites and to ensure in the planning that access between these sites and the port would be direct and unrestricted.

It was quite obvious that the planning of the town would have to go hand in hand with the planning of the port, and that the port would have to be developed in stages to suit the growth of trade.

Topographical Surveys and Soundings.

The first essential preliminary to almost all the physical investigation work was the establishment of a survey base line and bench marks and the adoption of a grid and levelling system for the job. For the job base line three points were chosen in a straight line along three quarters of a mile of the Portland foreshore from north to south of the project. The true bearing of this line and the distances between the points were accurately established by surveyors of the Lands Department at the request of the Trust in 1952. The points in the line were centre dots in brass plugs set in massive concrete blocks buried in the ground. The relative levels of the brass plugs were also fixed by the surveyors.

The job datum was adopted to coincide with the datum used by Portland Town, although this meant a difference of some 4½-in. from the datum of soundings adopted by the Public Works Department. The origins of the job survey grid were chosen so that there was little possibility of negative co-ordinates occurring for any point in the project.

Having established the base line and bench marks, traverses were extended along the coastline north and south, picking up existing survey stations and locating new points as required. From the base line and traverses the topography of the land and the contours of the sea bed were mapped.

A very complete marine survey had been undertaken by the Public Works Department prior to the Trust's operations, and in this field it was only necessary to fill in shore line details and to carry out the first of a continuing series of 4-monthly surveys of the sea bed to check seasonal and cyclical trends, and to observe any changes caused by the harbour construction.

It may be of interest to record here the method of marine survey used which made use of echo sounding and short wave radio. Each run of the echo sounding launch was controlled as to line by a theodolite and a survey station which kept the mast of the launch in the cross hairs and directed the launch driver to port of starboard by means of the radio. A surveyor in the launch kept checking the bearing of a chosen point on the beam by sextant, setting the reading up 2° after each reading, and watching for the shore station and the chosen check point to come into line in his instrument when he would press the marker pedal, marking the echo sounder chart, and set up the next 2°. The method is, of course, not new but is extremely simple and quick and reduces errors because it is possible to check constantly by radio telephone.

Winds and Waves.

In order to fix the layout of marine structures and to design the breakwaters it was necessary to study the winds and waves in some detail. Winds would affect the waves and littoral currents and also the handling of ships and the blowing of spray. Waves would attack the breakwaters, affect ships entering or leaving the harbour and the stillness of the enclosed waters and influence the direction and quantity of sand travel along the coast.

Records of winds in Portland had been taken for many years but purely by the judgment of observers without instruments. Records of waves were confined to the reminiscences of the fishermen, which were surprisingly useful.

In the absence of instrumental records of these important movements it was necessary to calculate winds and waves of the past from the synoptic weather charts which had been worked out and recorded daily by the Melbourne weather bureau for many years. In the meantime a recording anemograph was installed giving a continuous gust-by-gust record of the wind, and various wave recording mechanisms were evolved and installed to obtain information which would give a check on the calculations made.

The calculations of winds and waves of the past was done by the method adopted by Messrs. Sverdrup and Munk of the U.S. Hydrographic Office in 1947. The method, with developments, was used by the N.S.W. Public Works Department for providing data for the testing of the Port Kembla model in 1951, and their experience was freely offered to Portland.

The Investigation and Design for Portland Harbour, Victoria—continued

It will be appreciated that this "hindcasting" method of computing wave heights took no account of the natural protection afforded to the anchorage by the topography of the coast, and wave refraction diagrams had to be drawn to determine the wave characteristics at points in the anchorage resulting from the free waves of the open ocean beyond the confines of the bay (Fig. 3).

Some check on the theoretical result was obtained by instrumental observations of wind and waves at Portland. The recording anemograph was a standard instrument but the wave recording apparatus was a local development. The most simple and effective recorder consisted of a large wooden float in a confining tube which was perforated sufficiently for the float to follow the rise and fall of the main waves. The float was connected by a chain over a sprocket to a counterweight which kept the chain in tension. The rise and fall of water actuated the float and kept the chain sprocket spinning in alternate directions. The sprocket shaft alternately wound and unwound a thread which in turn moved a stylus across a recording paper strip. The whole apparatus was mounted on a pile in 33-ft. of water over the end of the Ocean Pier to which it was rigidly braced.

Variations of this machine were made with limited perforations in the pipe and a spring-controlled float which made is possible for the record to be confined to the long period waves of very small amplitude more usually known as "ground swell." The ground swell was expected to cause more trouble than the more spectacular short period waves where the stillness of the harbour waters was concerned.

This recording unit worked very well until, most unfortunately, the unit complete with pile and superstructure was washed away in a storm in 1954 while recording its last and greatest wave. However, by this time a sufficient record had been obtained to check the "hindcasting" methods of calculation employed, and to provide an indication of the characteristics of likely long-period ground swells.

From this study of past waves modified by the refraction diagrams it was possible to establish that south-easterly storms would raise waves of approximately 200-ft. wave length and 7-second period with a maximum amplitude of 13 to 14-ft., while south-westerly storms which might occur a great distance away in the Southern Ocean could produce waves in the anchorage approximately 500-ft. long and 5- to 6-ft. maximum amplitude with a period of 13 seconds.

It is interesting to note here that these figures give the high south-easterly waves a speed of just over 18 m.p.h., while the south-westerly waves were travelling at over 27 m.p.h. though very much lower in height.

It was decided that under the very worst conditions it would be just possible for wave trains of maximum amplitude to arrive at the anchorage at the same time from the two origins, producing 20-ft. high waves when coincident. It was computed that some 360 waves of this height could occur at the harbour site during a storm of maximum duration. It also appeared from the long period wave records that ground swells were quite common with amplitudes of the order of 3 to 6-in., but no closely consistent period could be observed. Two or three waves might arrive in a train at 3-minute intervals to be followed by variations in period from 2 to 5 minutes.

From data such as outlined above the following design directions were laid down:

The main breakwater, whose principal function would be to protect the harbour from short period waves, must be capable of withstanding 360 consecutive waves of 20-ft. height and 200-ft. length and 7-second period without becoming so severely damaged

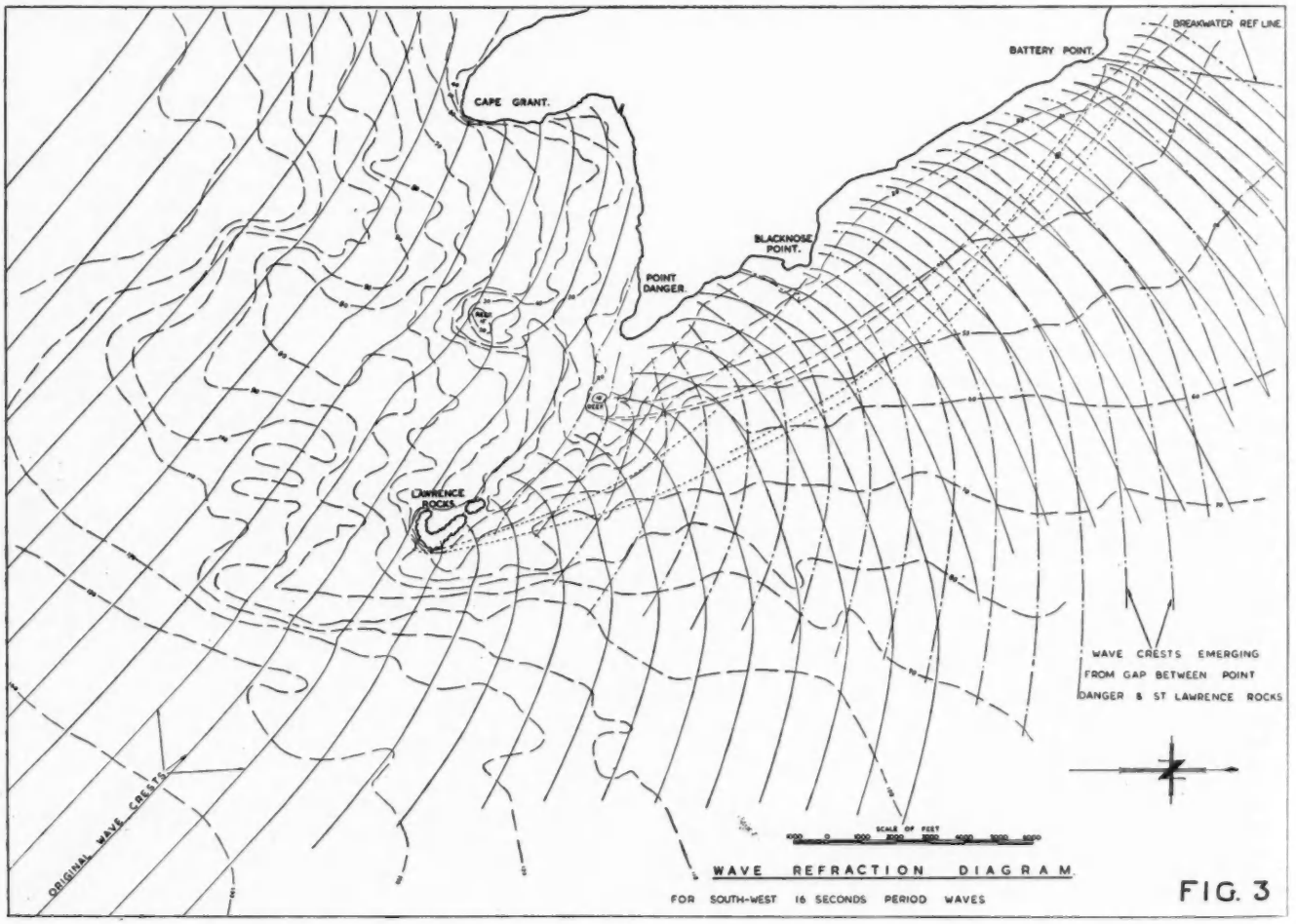


FIG. 3

The Investigation and Design for Portland Harbour, Victoria—continued

as to be incapable of withstanding a subsequent storm of normal maximum south-easterly waves of 13-ft. 6-in. height.

It was recognised that the design storm would be very infrequent and might not occur in a century, so that some damage could fairly be accepted.

As regards the effect of long period waves it was decided to carry out model tests to study the effects of waves of all the frequencies recorded on a harbour of the layout proposed.

Littoral Drift.

The coastline east and west of Portland is marked by sandy beaches backed by high sand dunes, some of which have to be carefully controlled to prevent them from travelling inland. The fishing harbours of Port Fairy and Warrnambool to the east feel the effect of drifting sand, and Warrnambool can only be kept open by regular dredging. To the west, the South Australian Harbours Board recently completed a coastal survey in connection with the possible establishment of ports on the coast between the Glenelg and the Murray, and they came to the conclusion that the drift of sand would be a serious problem to contend with. The possibility of sand accretion in Portland due to littoral drift was therefore not to be lightly discarded.

Observers in Portland supported a theory that the main travel of sand in the anchorage was on- and off-shore in cycles, and that the beach travel was a very local migration reversing with the seasons. A series of current surveys produced most inconclusive results in deeper water, and ordinary methods of observation gave little indication of any definite trend close in-shore. It was considered necessary, therefore, to carry out some rather more elaborate tests which might be more sensitive, and suggested use of radio active sand as a tracer was at one time investigated.

The Mineragraphic section of the C.S.I.R.O. was consulted at this juncture, and they took up the problem with energy and enthusiasm and proposed a scheme with two main lines of study, which was adopted and put into action (Fig. 4).

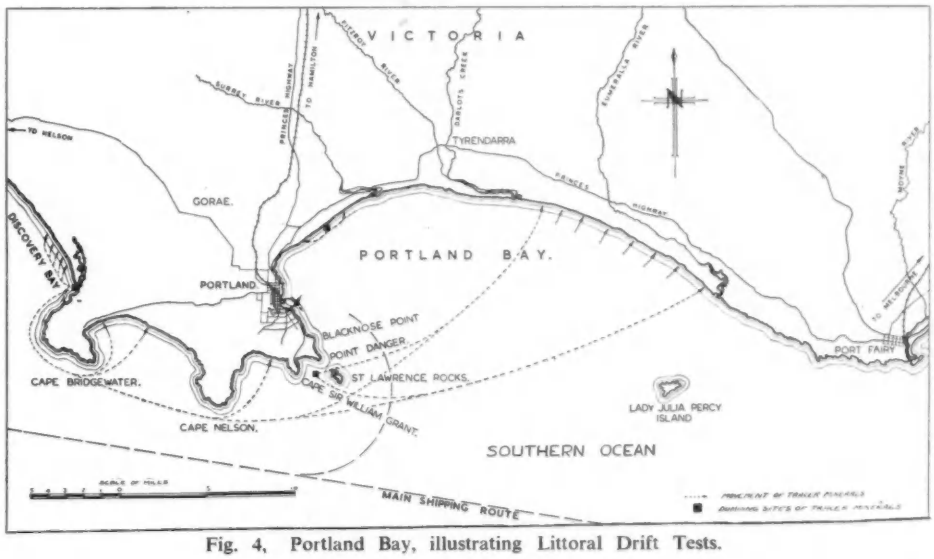


Fig. 4, Portland Bay, illustrating Littoral Drift Tests.

Firstly, the beach and sea-bed materials for 15 miles or so each side of Portland were to be sampled and analysed petrographically to find out their composition and possible origin. Cliffs and dunes were also to be examined as well as selected points on the sea bed.

Secondly, a number of tracer minerals was selected to be dumped at various points along the coast to east and west of Portland. These tracers were selected because they were entirely absent from local beach and sea-bed sands and could be spotted in minute traces in them. The minerals were rutile, sheelite tailings (garnet), pyrite and roasted pyrites; all were ground to suitable fineness and dumped in quantities up to 20 tons at five selected points. Two of these points were in the future harbour area—one in the breakwater line and one on the beach—and the other three along the coast, two to the west and one to the east.

Beach and sea-bed sampling proceeded immediately after the dumping and the samples were collected, sieved, packed and sent off to the Mineragraphic Section one after the other and the results were wired back.

The pattern of the travel of the littoral material soon began to be traced, and on completion of the tests in 1955 the Section was able to report that there was a definite strong drift of sand from west to east, but that after having been carried around the headlands which shelter the Portland anchorage it swept across Portland Bay to the Narrawong Beach, thus by-passing the Portland anchorage entirely.

Previous conclusions were thus confirmed that sand movements in and around the anchorage were likely to be irregular and local and that siltation problems were unlikely to be severe in the new harbour. No evidence of any extensive beach travel emerged such as might cause trouble if interfered with in the construction of breakwaters. A paper on this test has been presented before the Royal Society of Victoria by the Officers of the Mineragraphic Section of the C.S.I.R.O.

As may be imagined, these conclusions were most welcome and enabled a forecast of the probable siltation pattern to be made. It was expected that some accumulation of sand would occur on the seaward side of the main breakwater and that the formation of a small sand bar just outside the main breakwater head should be anticipated. From observations made on the original fishermen's breakwater it was thought that the accretion would be of an order of quantity well within the capacity of a small dredging pump.

Foundation Conditions.

The construction in the past of at least three open-sea piers by piling had provided an indication of the nature of the sea bed. Basically the floor of the sea was known to be limestone varying in consistency from almost a compacted sand to a limestone of flint hardness in some crusts. Patches of sand were found from place to place overlying the limestone and also occasional patches of boulders of man-handled size. The limestone had been eroded and dissolved away in parts in the past, forming gulleys and cauldron-shaped holes which had become filled with sand and clay or a clay-sand mixture. This information was known from divers' inspections and from observations made while driving the 5,000 or so piles in the old piers which penetrated into the sea bed up to 15 or 16-ft. in water depths up to 32-ft.

Experiences at Warrnambool harbour and elsewhere indicated further that cavities might exist in the limestone not very far below an apparently hard crust and that foundations were unlikely to be sound or uniform.

In 1948, the Public Works Department commenced a programme of marine borings using a steel tower which could be sunk into position on the sea floor or raised with buoyancy tanks and towed away. The borings were mainly of the percussion wash bore type with provision for resort to a rotary drill in cases of difficulty. The results of these borings confirmed forecasts of the condition of the sea bed to depths up to 117-ft. below low-water. Some cavities were traced but there was little information which could lead to the tracing of any definite pattern of cavities.

On taking over from the Public Works Department the Harbour Trust made arrangements to continue these borings over selected areas in order to obtain a more detailed picture on the line of the new wharf and to attempt to recover some undisturbed samples which might provide material for testing. Instead of using a tower, the Trust continued boring from a moored barge with the intention

The Investigation and Design for Portland Harbour, Victoria—continued

of removing some of the restriction of free jetting which had tended to undermine the stability of the tower when it was working on a sandy or soft patch.

The general principle of boring was the same as that used by the Public Works Department except that samples intended to be " undisturbed " were taken of representative materials by driving a 3-in. tube into the stratum and subsequently splitting the choked tube. A total of nearly 100 bores to 117-ft. below the sea bed were sunk by the Public Works Department and by the Trust.

Within the average of 50-ft. penetration tested in these bores it was concluded that strata, particularly near the shore, could undoubtedly vary from limestone to soft clay in distances of 20 or 30-ft. or so, and intentions of constructing massive wharf structures had to be reluctantly discarded. Shear tests on the weaker materials recovered gave no hope of minimum foundation loadings better than $\frac{3}{4}$ ton/sq. ft.

In order to obtain a confirmatory record of the sea-bed strata in the line of the wharf, three trial pits each 20-ft. square in plan and up to 20-ft. deep were sunk by grab barge. In the first hole at the in-shore end of the future wharf, a very hard limestone crust was encountered and this was broken up by using " bee-hive " blasts containing 5 lb. of gelignite each. The equipment used for excavating the trial pits was a Harman E20 dragline unit mounted on a 64-ft. x 24-ft. barge and operating a half-yard grab. The grab unit delivered its spoil to a barge of the same size mounted with eight steel tipping skips of 10 cu. yd. capacity each. These skips shaped like truck bodies were arranged four on each side and tipped with hydraulic rams.

Quarry Investigations.

In order to locate sources of stone for breakwater and concrete construction and of sand for use in concrete, it was necessary to make a wide survey of possible quarry sites and, having narrowed the field, to make detailed surveys at selected points. The search for stone for breakwaters was not a new one and tentative sites had been probed in the past in the cliffs adjacent to the harbour at Battery Point, and in a basaltic flow at Gorae, 5 miles to the north of the site, and in a surface flow of basalt at Tyrendarra, 17 miles around the bay (Fig. 4).

Geologically, the district has an underlying stratum of limestone many thousands of feet thick overlain with basaltic flow material with several more or less local points of origin. The limestone which is exposed in the sea bed and in the white cliffs at the north of the town is normally of the consistency of soft chalk but with harder and sometimes flint-hard crusts at intervals. The basalt varies from a sticky clay, boulders bedded in clay, to rock sometimes soft or vesicular or more rarely hard glassy and dark blue in colour earning the name of bluestone. Occasional large areas of volcanic tuff of considerable durability exist.

The three Capes, Bridgewater, Nelson and Grant, all have solid basalt cliffs overlain with clay overburden which is itself in places buried under ancient sand dunes protected by an indurated crust. The limestone formation was too soft to be taken into account as a material for harbour building, and the indurated crusts of dune stone were not durable enough or sufficiently abundant for consideration. By far the most abundant occurrence of usable basalt rock was in boulders bedded in clay, and the quarry opened up by the Public Works Department at Gorae, five miles away, was in such a formation. The cliffs at Battery Point had been riddled with exploratory drives in the past but only a very soft rock, best described as " rotten rock," was exposed.

A surface flow of basalt in the stony rises at Tyrendarra, 17 miles from Portland, had been opened up experimentally by the Department and gave promise of great quantities of tough vesicular basalt in a flow bed not more than 25-ft. thick, unencumbered with clay or other overburden. Various small quarries also existed which had been opened up in the past to provide " bluestone " for the early principal buildings in Portland. The Capes of Bridgewater, Nelson and Grant all contained a dense basalt, but quarries in Nelson and Grant would face a big overburden problem, while the 400-ft. high basaltic plug at Cape Bridgewater presented a 14 mile haul over lightly built roads.

The examination of these various sites was done by a drilling team operating a Mindrill E100 diamond drill. This is a light and efficient unit for exploratory work in rough country, but is at its best in hard solid rock and not particularly suited to piercing the boulder and clay overburden of many of the sites tested. The results of these bores narrowed the search ultimately to two main probabilities, the one at Tyrendarra with no overburden and a 17 mile haul, and the other at Cape Grant with 30 per cent. overburden but only a 4 mile haul.

In the final analysis, Cape Grant proved the best prospect as the short haul would be on a private road permitting the use of off-highway type transport, while a large part of the overburden was usable as reclamation material and as a base course for construction roads. Tyrendarra's 13 mile haul differential placed a premium of nearly 10s. per ton on rock from that source, while the overburden removal cost at Cape Grant together with construction of special roads did not approach this figure.

Test faces were then opened up at Cape Grant to try to gain some impression of the way the stone would quarry and what sizes and proportions of stone sizes could be expected. These test faces were opened under considerable difficulties in the near vertical face of the cliffs of the cape. This entailed much rope work to begin with until suitable benches had been formed.

From these tests and also from observations of similar basalt beach boulders it was decided that stones up to 8 tons in weight might be expected, and that stones over 1 ton in weight were unlikely to exceed 15 per cent. by volume of the output.

While these tests were going on it was necessary to make a start with breakwater construction so that confidence in the project could be encouraged as a preliminary to the arranging of finance. To this end a small quarry at Blacknose Point only $1\frac{1}{2}$ miles from the main breakwater site was opened up in a deposit of low grade clay and basalt but producing some to 40 to 50 per cent. of usable breakwater stone up to 4 or 5 tons in weight. The deposit occurred in 70-ft. high cliffs above a stony beach with a clay overburden layer about 8 to 10-ft. thick. This overburden was pushed over the cliffs by bulldozer to form a bench on the stony shore below on which quarry operations began.

Concrete Materials.

In the first days of investigation it was feared that insufficient suitable stone would be available for the construction of rubble mound breakwaters and that concrete breakwaters would almost certainly be necessary. Initially, therefore, the search was concentrated on concreting materials, and a very wide area was covered in the search for aggregate, sand, cement and pozzolans.

The search for aggregate was a part of the quarry investigation and, as already described, the quarry at Cape Grant was expected to provide a source of material for the breakwaters and for crushing as well. In addition, some 60,000 cu. yd. of beach pebbles were available from the foreshore beaches of Blacknose Point and Point Danger.

As regards sand the local beach and dune sands proved too fine in grading to be of any use, and various small local deposits of a coarser sand were also inspected and rejected.

It was known that the bed of the Koroit Creek at Coleraine provided large deposits of a first quality concreting sand but it was hoped that some source closer to Portland would be found, and a detailed inspection was made of the rivers and creeks of the district from the Glenelg in the west to the Eumerella in the east. Small sand banks of suitable sand were found in some of the rivers but generally small in extent and frequently almost inaccessible.

The two main possibilities remaining after elimination of the smaller deposits were the Coleraine deposit or crushed sand made by ball or hammer mill at the quarry. Economic considerations favoured the Coleraine sand in spite of the 75 mile haul, and concrete experiments were then put in hand using this material.

At the time when these investigations were in hand the supply of cement was very unreliable, and economy in cement was a requirement particularly stressed. To assist in cement economy the possibility of using local pozzolanic materials in the concrete was investigated. Very large deposits of volcanic tuff were available all around Portland and their pozzolanic value was tested. Some of these tuffs were undoubtedly suitable for use as pozzolans after treatment which would generally mean grinding to – 200 size in a ball mill.

(Continued at foot of following page)

New Ore Pier at South Philadelphia

Modern Installations Increase Handling Capacity

By J. ALEX. CROTHERS (Director, Port Development, Delaware River Port Authority)

Early in 1954, the Pennsylvania Railroad completed a new facility for the handling of import ore at South Philadelphia. Situated at Greenwich Point adjacent to the Railroad company's coal dumper, approximately 95 miles from the Atlantic Ocean, this new ore pier is contributing greatly to making Philadelphia one of the leading ports in the United States for handling ore imports from South America, Labrador, Africa, and other foreign sources of supply.

When placed in operation in March, 1954, this new pier represented an investment of approximately $9,000,000. It is 850-ft. in length and can accommodate two vessels but it is ultimately planned to extend the length to a 1,250-ft. pier with a capacity of four vessels. For the construction of the pier the Delaware River was dredged to a depth of 39-ft. in that area, a total of 1,210 reinforced concrete piles ranging up to 89-ft. in length were manufactured on a production line basis, railroad tracks were laid to the edge of the river and a temporary pier built to carry out the task of floating the piles into position for driving. Hundreds of workmen were employed on this project which was started early in 1952.

While the pier was being constructed, work was in progress on the laying of the miles of track and the erection of the various maintenance buildings necessary to link up the new operation with the present extensive classification and service yards in South Philadelphia.

The pier was equipped with two electric unloading machines built by the Industrial Brown Hoist Company at its Bay City, Michigan, plant. The grab buckets on these machines are each of 225 cubic foot capacity, lifting approximately 20 tons at a single bite. The cranes to which they are attached have a reach of 72-ft. on each side of the pier, with a bucket clearance of 57-ft. above high water. The combined hourly rated capacity of these machines is 2,800 tons per hour of average weight ore, and 3,600 tons of heavy ore.

Two 54-in. wide belts, installed by Heyd and Patterson, Inc., of Pittsburgh, Pennsylvania, convey the ore to a loading house from which it is dumped into freight cars through 40-ton weighing hoppers. These cars run down by gravity to the new classification yard which has a capacity for 1,000 hopper cars, where they are made up into trains for direct movement to steel making centres.

In addition to the huge volume of iron ore transported to the western Pennsylvania, Ohio, and West Virginia steel producing areas, a considerable volume of the iron ore required at the Fairless Plant of United States Steel, which is situated up the Delaware River at Morrisville, has been handled over the new ore pier at Greenwich Point. Although the U.S. Steel plant has its own dock and facilities for the handling of import ore, the present 25-ft. draft of the channel between Philadelphia and this upriver plant restricts the use of the larger ore-carrying vessels. These, however, are easily accommodated at Greenwich Point.

During 1954, over a million tons of ore were handled at this new facility, which is operated by the Pennsylvania Tidewater Dock Company, as lessee. During 1955, the total was raised to over three and one-half million tons, while a total of between four and five million tons was handled during 1956.

Aerial view of the new ore pier at South Philadelphia.

In July, 1955, the capacity of this ore handling pier was increased substantially by the addition of a third unloader. Built by the Dravo Corporation, this machine is electrically powered and incorporates the latest refinements. Its large buckets scoop ore from ship holds in 25-ton grabs every 45 seconds. Capacity of the pier, with the addition of this third machine, was raised to a maximum of 5,400 tons per hour.

The increase in ore movement over the pier in 1955 caused the Pennsylvania Railroad to order yet another unloader, which was placed in operation at the end of last year. This fourth machine, also built by Dravo, increases the capacity of the pier to a maximum of 7,200 tons an hour. The total annual capacity therefore of this facility, equipped with the four unloaders, is now between eight and ten million tons of import ore.

The railroad's investment in this pier, now totalling approximately $12,000,000, has made a definite contribution to the overall development of the Delaware River Port Area. In constructing the pier adjacent to the present coal dumper of the Pennsylvania Railroad an ideally efficient layout was achieved. Formerly, thousands of hopper cars carrying coal eastward for fuelling Philadelphia industries or for the export trade returned empty to the mines of western Pennsylvania and West Virginia. These trucks now carry the imported ores back to steel centres which are in the same general territory. Thus the cars that now transport coal in one direction will haul ore in the other.

Portland Harbour, Victoria—continued

Together with the search for concreting materials a series of experiments was put in hand to test the technique of making underwater concrete by grouting instead of depositing by Tremmie or by placing precast blocks; this was still with the idea of building mass concrete breakwaters and wharf walls.

It was felt that mass structures under water, whether in the form of precast blocks or Tremmie or skip-placed concrete, would require a degree of skill and a standard of equipment and precision far higher than that needed for grouting up a ballast-filled steel form, and that economy in cement could also be expected in the use of a grout with pozzolan added.

The experiments took the form of grouting underwater in an 8-ft. x 5-ft. x 2-ft. box with perspex inspection panels. The aggregate used was a rounded beach aggregate not smaller than 1-in., and various grout and pozzolan mixtures were tried. The conclusion was reached that this method of concreting underwater could be conducted with a smaller number of skilled technicians than by more conventional methods and could produce a concrete of adequate strength for the purpose required.

As matters developed, the use of underwater mass concrete was not possible for breakwater or wharf for reasons described later, and the principal application of this grouting method was in the foundation for the 100-ton slipway.

(To be continued)

Port Adelaide Improvement Plans

Plans for harbour development at Port Adelaide are now before the State Parliament of South Australia. It has been recommended that the swinging basin be increased to 600-ft. to accommodate modern sugar carriers and that a tug pen of seven berths be built. The cost of the improvements, it is estimated, will be £A806,000.

Modern Dry Docks: Design, Construction and Equipment

II. Cranes for Dry Docks

By H. H. BROUGHTON, M.I.C.E., M.I.Mech.E., M.I.E.E.

IN the memorandum on "Construction and equipment of dry docks," issued by the Institution of Civil Engineers, attention is drawn to the fact that a dry dock is a factory within the meaning of the Factories' Act, 1937. The latter contains requirements (a) of a general kind likely to affect cranes; and (b) specifically applying to cranes. Although there is no statutory duty laid upon a maker as such, it is recognised that those upon whom legal obligations are placed have to rely upon the makers in regard to requirements which are basically matters of design. Adherence in the design of a crane to the permissible stresses and standards of construction laid down in British Standard Specifications should go far towards satisfying the general requirements as to construction, soundness and strength, and should ensure compliance with many other statutory requirements. In this article, which deals principally with the heavier cranes, we shall have occasion to refer to certain of these specifications as they indicate such fundamental principles as appear desirable without hampering the freedom of the crane maker in his selection of the most appropriate design, or mode of construction, for the purpose in view. Thus, welded and tubular construction, in whole or in part, is permitted, and the designer is at liberty to use one or more specified grades of structural material for load bearing members and, if he wishes to do so, light alloys for platforms, stairs and sheeting.

Irrespective of the size of the dry-dock, cranage facilities should be such as to make provision for: (a) infrequent handling of the heaviest items likely to be removed from or put on board a vessel under repair; (b) occasional handling of medium loads; and (c) frequent handling of 5- to 10-ton loads. A standard gauge track along the coping enables low-truck jib cranes to handle the lighter material required in the dock itself thus leaving the larger cranes free to carry out the work for which they are suited. In addition, all crane and rail tracks should be laid flush with the coping so as to afford unrestricted movement of low-capacity mobile cranes and other traffic in the neighbourhood of the dock.

Duties (a) to (c) are best performed by one or more self-propelled high-pedestal luffing jib cranes each having a high-speed auxiliary hoist and an outreach of the main hook sufficient to plumb or, preferably, to extend a distance of about 10-ft. in front of the centre-line of the dock. The height of the pedestal is determined by the height of the vessel's superstructure above the coping end. In this connection, it is of interest to note that the superstructures of the largest liners are 120-ft. above keel line. Slewing through a complete circle is necessary. Differences of opinion exist in regard to luffing, some users favouring a screw- or rope-operated motion, with or without compensation, while others prefer a balanced level-luffing motion. The latter is desirable for cranes of low-tonnage capacity and has been successfully applied to the luffing motions of many large cranes.

To ensure freedom from damage either to the parts being lifted or to the ship's structure and equipment, the operations necessitate small movements at slow speeds of all motions. These requirements determine the type and range of control as well as the braking arrangements.

High-tension three-phase A.C. distribution is standardised in many countries and bulk supplies of this kind are customary. For general industrial use the current is transformed down to 400/230 volts, but this does not mean that the cranes must, of necessity, be driven by A.C. motors. Recent developments in A.C. motor control, to several of which reference will be made, have resulted in improved performance, and are being increasingly used for general-purpose cranes. For certain motions of special-purpose cranes, such as high-capacity dry dock cranes handling valuable loads of many different sizes and weights which necessitate controlled creeping speeds, D.C. motors arranged for variable-voltage control are superior to A.C. induction motors. Conversion of A.C. to D.C. is straightforward and can be effected either in a nearby static substation or on the crane.

Before proceeding it is advisable to indicate briefly the effect of humidity on the structural parts and electric equipment of all cranes working on exposed sites at sea level, and to emphasise the precautions which have to be taken in order to ensure satisfactory performance.

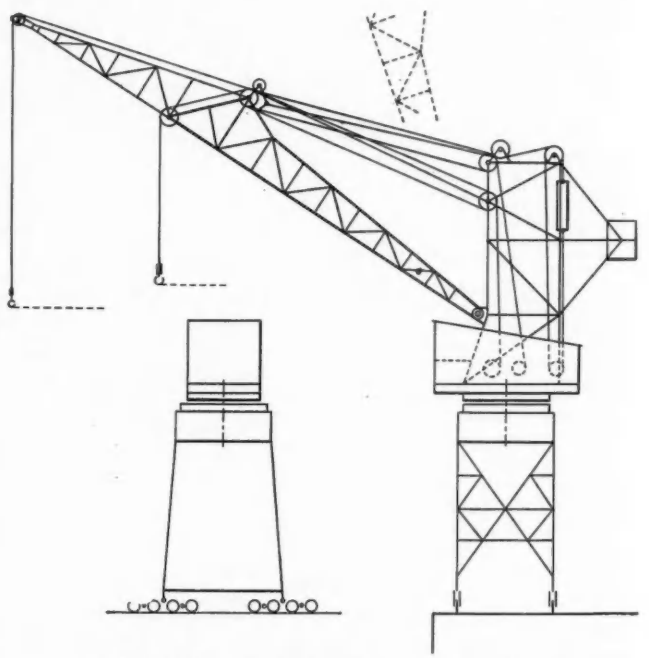


Fig. 1. Balanced level-luffing crane (Stothert and Pitt).

Effect of Humidity.

On many occasions attention has been drawn to the harmful effects of the climatic conditions under which cranes have to work in tropical countries. They affect not only the structure but also the whole of the electrical equipment. In regard to the former, provision can be made by including a corrosion factor in assessing the permissible stresses to be allowed in designing the main structural members; but the only course open to the electrical engineer is that of using insulating materials which are unaffected by moisture, and of preventing condensation in motors and on control gear.

Assuming an average temperature of 60° F. in Britain and 90° F. in a tropical country, then 90 per cent. relative humidity means that there is 2½ times more moisture in a tropical climate than in Britain and, on reduction to dew point, 2½ times more

Modern Dry Docks—continued

moisture is precipitated on insulators and absorbed by insulating materials.

High humidity of the air necessitates avoidance of condensation of moisture on the motor windings and switchgear and in the controllers. The use of materials in the least degree hygroscopic is inadmissible, and means for warming the windings of each of the motors and generators are essential. The rating of the non-

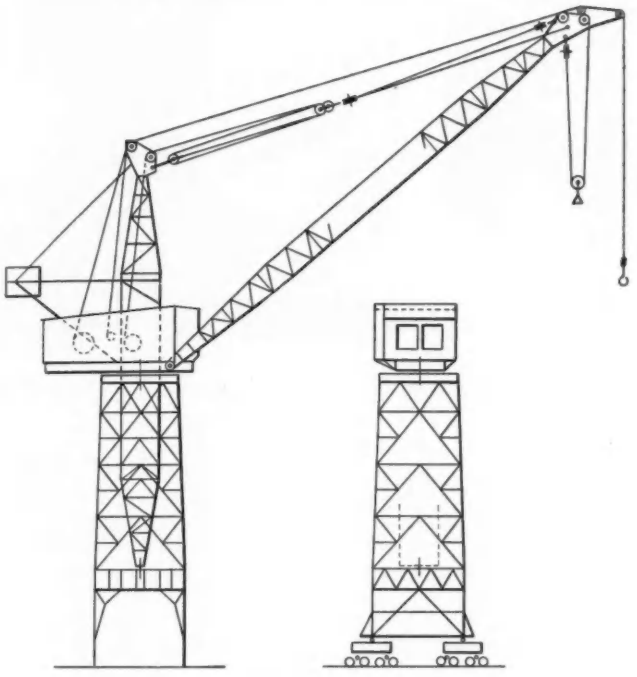


Fig. 2. Rope derricking crane (Butters Bros.).

luminous heaters required for this purpose is quite small, averaging about 0.4 kw. for a 90 h.p., 500 r.p.m. motor, and is such as to maintain the temperature of the frames at approximately 9° F. above the ambient air temperature. To preserve the insulation of the motors care should be taken to ensure that the heaters are not fixed in contact with or in close proximity to the windings. In this respect with some of the smaller frame sizes, particularly A.C. machines, difficulty may be experienced in locating the heaters.

Top and bottom ventilation of the metal cases of all contactor panels, fuseboards and the like is necessary, and the ventilating apertures should be covered with fine-mesh metal gauze to prevent the ingress of insects. This requirement is specially important for plant intended for service in tropical countries.

Capacities and Speeds.

Capacities and speeds of typical jib cranes are given in Table I from which it will be seen that load ratings vary from 20 to 75 tons, and maximum outreaches of the main hook from 75 to 110-ft. Main hoist speeds vary between comparatively narrow limits and average about 25-ft. per min. Slewing speeds are determined by the maximum radius and can be expected to vary from 0.33 to 0.5 rev. per min. Of the cranes listed only those under Refs. 1 and 3 are geared to travel at 150-ft. per min. whilst for the remainder the speeds are 40 to 70-ft. per min. Luffing speeds show a 15-fold variation from 6 to 93-ft. per min.

The wide differences disclosed in the table, and the changing pattern, make it difficult to forecast future requirements, but a 50/10-ton crane having main-hoist working radii variable from 50 to 115-ft. with suitable control will give good service if designed for the following speeds: Main hoist, 20-ft. per min.; auxiliary hoist, 90-ft. per min.; slewing, 1/3 rev. per min.; luffing, 30-ft. per min.; and travelling, 100-ft. per min. For the main hoist motor D.C. variable-voltage control combined with field weaken-

TABLE I. Capacities and Speeds of Typical Cranes.

Reference	1	2	3	4	5	6	7
Main hoist, tons	75	50	45	40	35	30	20
Auxiliary hoist, tons	15	15	5	5	5	10	3
Working radii—							
Main hoist, ft.	56-105	40-110	33-82	43-90	-110	40-85	35-74.5
Auxiliary hoist, ft.	64-123	-120	35-120	150	-132	60-135	47.5-106
Height of Lift—							
Above coping, ft.		100(125)	105			65(80)	72(93)
Below coping. ft.		60					45
Rail centres, ft.	40	30	33.5	37	25	25	20
Speeds							
Main hoist, ft. per min.	18	25	26	25	30	15(30)	25
Auxiliary hoist, ft. per min.	78	40(80)	122	120	120	45(90)	165
Luffing, ft. per min.	13.75	6	93	40		60	13.2
Slewing, rev. or ft. per min.	0.36	0.4	0.82	250	250	0.5	0.5
Travelling, ft. per min.	150	60	150	70	50	40	60
Powering							
Supply	D.C.	A.C.	A.C.	D.C.	D.C.	A.C.	A.C.
Control	R	V-V	V-V;R	R	R	R	R

ing will be found to give a wide range of speeds under varying loads; and for the other motions A.C. operation will be satisfactory.

Typical Arrangements.

Three arrangements are shown diagrammatically in Figs. 1 to 3 and, apart from the luffing gear, the principal difference between them is in the method of supporting the revolving superstructure, the weight of which, with full-load on the hook, can be expected to be about 300 tons for a 50-ton crane of 100-ft. radius. From Fig. 1, which design has been extensively used by British and, more recently, by American engineers, it will be seen that the

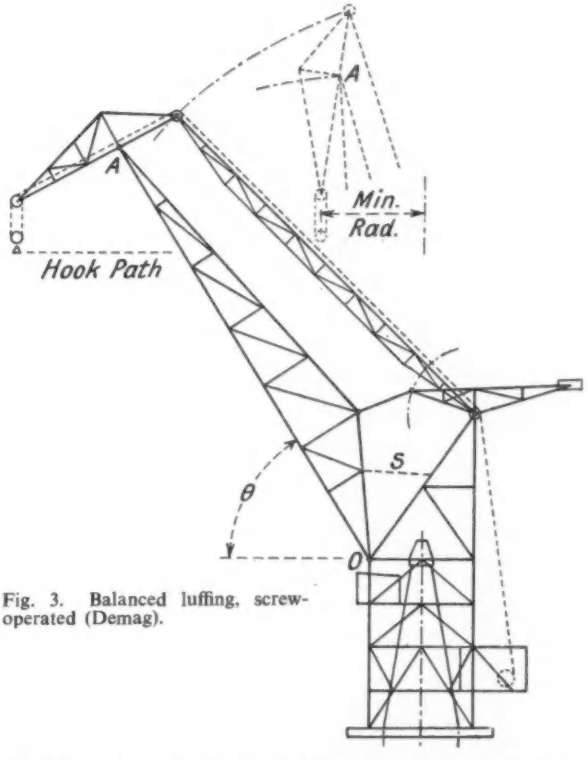
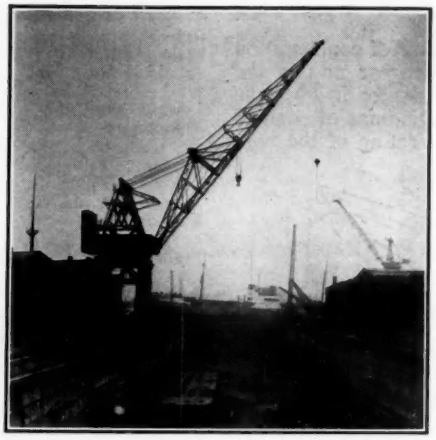


Fig. 3. Balanced luffing, screw-operated (Demag).

superstructure is mounted on a live-ring concentric with a centre-pin at the top of the pedestal. The diameter of the roller-path is such as to ensure that under all conditions of loading the resultant is well within the path, but the centre-pin and its attachments are designed to withstand substantial tension.

Alternatives to the live-ring are: (i) turret mounting which re-

Modern Dry Docks—continued



Left: 50-ton Screw Luffing Crane, manufactured by Stothert and Pitt Limited. **Centre:** 50-ton Arrol Crane, recently installed at the Swan Hunter dock at Wallsend-on-Tyne. **Right:** 80-ton Portal Jib Crane, level luffing, installed at Durban by Babcock and Wilcox Limited.

tains the centre-pin but dispenses with the radial-rods; and (ii) bushed truck wheels arranged in equalised pairs, at the front and back of the superstructure, together with a centre-pin in a trunnion-mounted bearing. In both of these the main slewing curb can be located inside the circular track whereas with live-ring construction the curb has to be placed outside the track in order to clear the radial rods.

Arrangements shown in Figs. 2 and 3 are favoured by engineers on the Continent and have also been used in a number of instances elsewhere. In both, the method of mounting gives rise to a couple (Fig. 4) on the pedestal the moment of which is equal to the tipping moment of the revolving superstructure. The bearing, A, is designed to withstand vertical and horizontal loading and may be of the self-aligning roller type or of the oil-pressure pivot type. Typical of the former is the SKF self-aligning bearing (Fig. 5), in which the harmful edge pressures due to malalignment are eliminated by using spherical rollers immersed in an oil bath. Bearings of this kind in a wide range of capacities have been standardised for light, medium and heavy duty.

Fig. 6 shows the oil-pressure pivot bearing introduced by Werf Gusto, Schiedam. The steel casting A, attached to the top of the truncated conical tower B, is surmounted by a phosphor-bronze head-plate with an accurately-machined and high-polished spherical surface which allows the bearing to correct slight errors of alignment. In contact with this head-plate is a forged steel cap which is secured to the superstructure. Pressure oil entering at the top of the bearing fills the balance chamber C and, when the pressure is sufficient, the rotating part of the loaded crane is lifted bodily and supported by the oil in this chamber. The oil is then distributed over the spherical surface of the bearing and, when this happens, the pressure is reduced to about 1,000 lb. per sq. in. A trough, D, pipe-connected to the sump, catches the spent oil which, after being filtered, is re-circulated. Interlocks in the control gear prevent initiation of the slewing motion till the pump motor starter is in the "on" position and the stop valve open.

The loads to be carried by the pivot bearing depend upon the capacity of the crane and, for a crane rated at 50 tons and having an outreach of 100-ft., the horizontal load will be in the neighbourhood of 100 tons. Referring to Fig. 4 (a) and (b), the force at B is resisted by a horizontal pressure ring consisting of a number of bushed cast-steel rollers mounted on vertical axles in equalised pairs at the front and back of the crane and in contact with a circular track secured to the tower. Other transverse rollers may be required to take care of wind pressure effects on the structure. Provision for counteracting wear and for adjusting the rollers is conveniently made by eccentrically-boring the holes in the bearings through which the fixed axles pass. It is advisable to restrict the pressure on the rollers to 1,200 lb. per inch of diameter per inch of effective width; and a necessary provision is a substantial backing plate between the roller path and tower to distribute the load.

Structural Steelwork.

The structural portions of the crane consisting of the jib, revolving superstructure and substructure, are designed to resist all the loads or combinations of loads sustained under service conditions without exceeding the permissible working stresses laid down in B.S. 2573. Amongst the forces to be included in designing the jib are those due to: (a) the load on the hook; (b) the weight of the jib and its attachments; (c) acceleration (retardation) forces in slewing the load and jib; (d) wind pressure of not less than 5 lb. per sq. ft. acting on the load and jib; (e) a transverse shear of 2½ per cent. of the maximum axial load; and (f) forces due to luffing when these act simultaneously with the foregoing.

Evidently in assessing the force due to the load on the hook, allowance must be made for impact, the effect of which is under investigation at the present time, as also is that of luffing. Hitherto, a designer has had to rely on his judgment, and authoritative data deduced from controlled tests will be helpful, particularly as regards luffing.

Welded construction is now extensively used for the sills and trucks of the substructure, and for the machinery platform of the superstructure; and to a lesser extent for jibs. Transport of large assemblies and erection difficulties on site often necessitate riveting of the superstructure and high-pedestal. A judicious combination of both methods is a practical solution. Nowadays it is customary to machine the live-ring roller paths after partial assembly in the works of the top of the pedestal and supporting girders, or after site erection of the substructure, and it is the practice of some makers not to machine the roller track to the correct contour till the platform girders are fixed. Joints in both roller tracks should be non-radial.

Working Stresses.

Since the conditions under which a dry-dock crane has to work imply infrequent handling of heavy loads, occasional handling of medium loads, and frequent handling of light loads, the allowable working stresses in the structure correspond to those recommended by the British Standards Institution for fitting-out cranes and defined as Class I in B.S. 2573 "Report on permissible stresses in crane structures."

On the understanding that all calculable stresses are taken into account, the permissible working stresses for structures of this class, when made of 28/33-ton steel to B.S. 15, are set out in Table 2. These tabulated stresses, which have been rounded off, are expressed in lb./sq. in. to avoid the confusion which arises from the use of long, short and metric tons.

From the basic stresses given in B.S. 2573 similar tables can be compiled for high-tensile structural steel, and for Class 2 cranes.

Modern Dry Docks—continued

TABLE 2. **Permissible Working Stresses (B.S.15 Steel) for Class I Cranes.**

	Stress, lb./sq. in.
Parts in tension:	
On the nett effective section for axial stress	17,000
On the nett effective section for extreme fibre stress (in bending)	
For plate girders	18,000
For beams other than plate girders	19,000
Parts in compression:	
On the effective gross section of main members for axial compression (for all values of $l/k \leqq 120$), $f_c = 19{,}300 - 98.6l/k$	$\leqq$ 17,000
On the gross section of compression flanges	
For plate girders	18,000
For beams other than plate girders	19,000
Parts in shear:	
Maximum shear stress	13,500
Parts in bearing:	
On flat surfaces	23,000

The permissible compressive stress in main members entered in Table 2 is deduced from a straight-line formula which is in close agreement with, and is deduced from, the more complicated formula given in B.S. 2573.

In the absence of authoritative strain-gauge tests on jib cranes under working conditions, the effect of live loads is taken into account by assuming an impact factor of 1.2. This factor applies to the motion of the hook load in a vertical direction and makes provision for inertia and shock forces.

Should it be decided to adopt Class 2 rating for the structural portions of the crane, the above working stresses are reduced by 6 per cent. and the impact factor is increased to 1.35.

Main members made of 40/50-ton steel are sometimes called for but, on account of the difficulty experienced in recent years in obtaining the requisite sections, the use of high-tensile steel has declined. Basic stresses for such steels and for tubes are to be found in B.S. 2573.

When a crane is intended for service on the North American continent it is probable that the permissible working stresses would be deduced from the basic stresses given in the American Railway Engineering Association's "Specifications for steel railway bridges." Included in the specification are structural, silicon and nickel steels.

In tropical countries provision for excessive corrosion is necessary, and this implies adoption of lower working stresses than those given in Table 2.

Structural members subjected to axial compression and bending stresses are proportional so that

$$(f_a \div F_a) + (f_b \div F_b) \leqq \text{unity}$$

wherein f_a and F_a denote the axial compressive stress and permissible axial stress respectively; and f_b and F_b denote the maximum compressive stress due to bending and permissible bending stress respectively.

If difficulty is experienced in interpreting this relation it will be found convenient to express both sides as percentages. Thus, if from the known loading on and dimensions of the member the first term, 100 $(f_a \div F_a)$, is equal to say, 67 per cent. then the maximum value of the second term, 100 $(f_b \div F_b)$, is 33 per cent. if the sum of the two is to be kept within the prescribed limit of 100 per cent. In practice it is customary to proportion such members so that the sum of the two ratios is substantially less than the limiting value.

To extend Table 2 it is necessary to include acceptable loads on truck wheels, fixed-axle wheel bushes, rollers of live rings, and transmission screws.

For steel-tyred wheels the maximum load is 1,200 lb. per inch of wheel diameter per inch of effective width of rail head. A similar load, per sq. inch of projected area, is permissible for well-lubricated bronze-bushed bearings. These loads depend on service conditions and, whilst variations are to be expected, the values given apply to frequent operation of the travelling motion at linear speeds of 100 to 200-ft. per min.

For self-aligning roller bearing axle boxes an endurance of 15,000 to 20,000 hours is satisfactory, but when such bearings are to be fitted it is advisable to confer with the maker in order to determine the load rating.

The permissible loading on live-ring rollers is conveniently expressed in terms of the lesser Brinell hardness number of the surfaces in contact. For dry-dock cranes with smooth-machined rollers and tracks, the permissible load is:

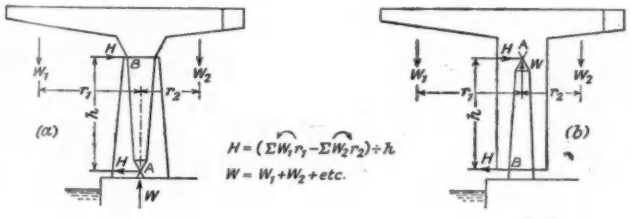
$$L = 5\,B \times F \times D, \text{ lb.}$$

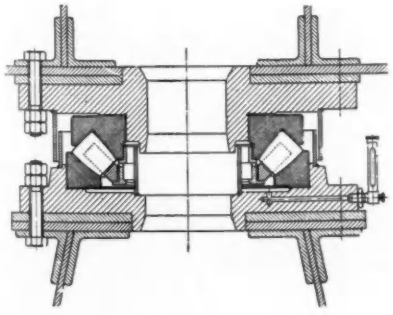
where B=lesser Brinell number; F=effective face width of roller, in.; and D=mean diameter of roller, in.

When transmission screws are used for operating the luffing motion they are arranged to mesh with articulated bronze nuts and, with good lubrication, a contact pressure of 600 to 700 lb. per sq. in. of projected contact area can be allowed. Such screws should be protected from the weather by telescopic or other shields.

Equaliser Trucks.

The number of truck wheels required at each corner of the crane pedestal depends on the capacity and radius of the crane,





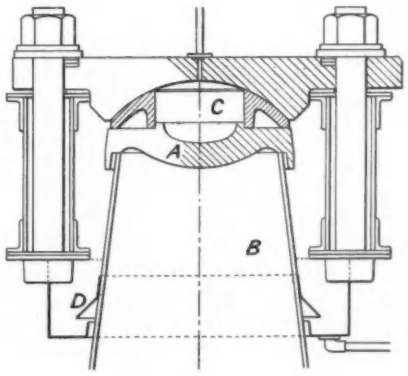


Fig. 4 (left). Pivot and pressure ring mounting. Fig. 5 (bottom left). Self-aligning roller pivot bearing (S.K.F.). Fig. 6 (bottom centre). Oil pressure pivot bearing (Gusto). Right. 10-ton Travelling Monotower Crane. manufactured by Butters Bros. and Co. Ltd.

Modern Dry Docks— continued

and is determined by the maximum corner load and permissible wheel loading. The latter seldom exceeds 45 tons and is influenced by the dimensions and properties of the wheel and rail. With the rail sections that are available centre-flanged wheels in contact with two rails are sometimes used for wheel loads of 40 tons and upwards. The maximum wheel pressure is computed for two conditions, namely, when the fully-loaded crane is at work with a light wind blowing; and when the crane is unloaded, and at rest in all motions, with a 40 to 50 lb. wind acting on the structure.

Restriction of load necessitates 2 to 8 wheels at each corner, adjacent wheels being mounted in pivoted trucks to ensure equal loading. When there are more than two wheels, the trucks are likewise equalised in pairs. Schematic truck arrangements for 2 to 8 wheels per corner are shown in Fig. 7, and Fig. 8 depicts the equaliser truck arrangement used for a 45-ton crane geared for a travelling speed of 150-ft. per min. and having six wheels at each corner of the pedestal.

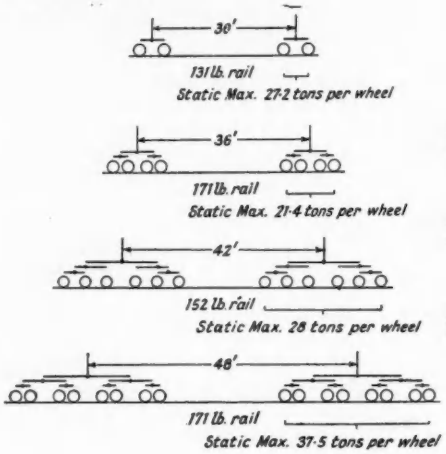


Fig. 7 (left). Typical truck arrangements.

Fig. 8 (below). Six-wheel equalised trucks.

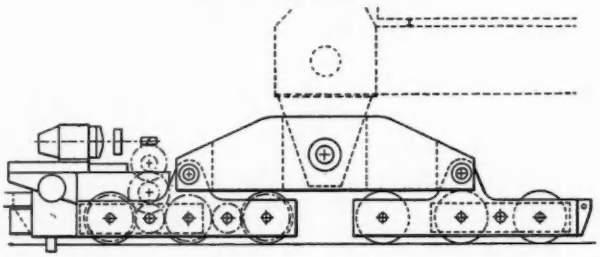
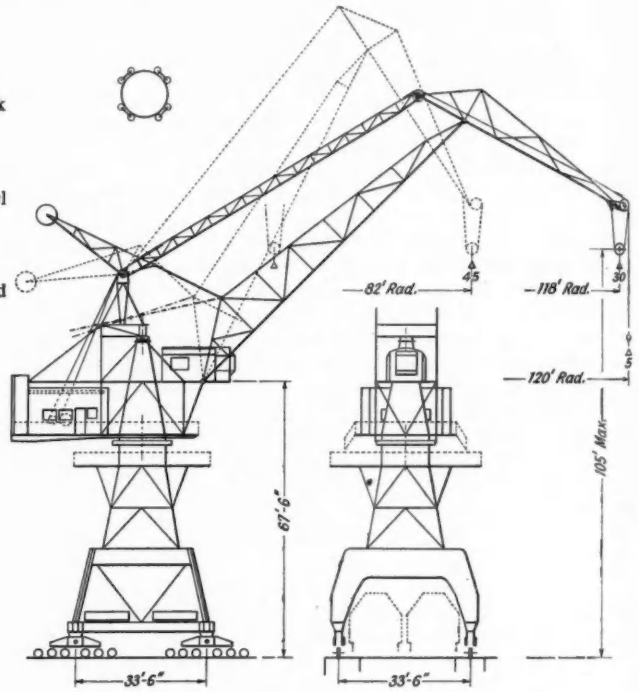


Fig. 9 (right). 45/5-ton balanced level-luffing crane (M.A.N.).



In detailing it is necessary to make provision for the easy removal of wheels from the trucks and, notwithstanding the small angular movement, it is advisable to arrange for automatic lubrication of all pivots. The trend is in favour of a separate motor at each corner geared to drive not less than half the total number of truck wheels. Increasing use is being made of worm reducers for driving the travelling motion.

Ladders and Platforms.

To comply with the Factories' Act safe means of access have to be provided to the driver's cabin, the machinery house and to every place where any person engaged on the examination, repair or lubrication of the crane has to work, adequate handholds and footholds being provided where necessary. In particular:

(a) Every platform has to be securely fenced with double guard rails and toe boards. Wherever practicable, an unobstructed gangway not less than 2-ft. wide is to be provided between any part of the crane liable to move and any guard rail, fencing or nearby fixture.

(b) Sides of ladders have to extend to a reasonable distance beyond platforms or some other reliable handhold has to be provided.

(c) Ladders have to be sloping wherever possible. If the slope of a ladder exceeds 3 in 1 and its length exceeds 30-ft., a resting place has to be provided approximately midway between the platform and the foot of the ladder.

(d) All permanent or temporary openings in any floor or platform have to be securely fenced.

Stability.

The static hook load which brings the crane to the point of tipping on its wheels in still air with the jib at rest and in the worst position is determined by calculation from the self-weights of the several parts and their locations with respect to the slewing centre. Such load, checked on site by test, is seldom less than three times the rated load without depending on the use of rail clamps, jacks or other anchoring devices.

Under operating conditions a minimum margin of stability of 2 to 1 is desirable when the crane, subjected to a 5 lb. per sq. ft. wind acting in any direction, is carrying its rated load with the jib at any radius and in any position. Depending on site conditions, the crane at rest in all motions, and with the jib at any radius and in any position, should be stable under the action of a 30 to 50 lb. wind coming from any direction.

Unless stated to the contrary, all stability calculations and site tests are based on the assumption that the track is firm and level. In making a static stability test, after adjusting the hoisting brake, care should be taken to ensure that the load is properly slung to avoid slipping, raised slowly without jerking, and held at rest a few inches clear of the ground.

Anchorage.

Adequate protection to resist the effect of high wind pressure is essential since the "sail area" of the structure, subjected to a 30 to 50 lb. wind, may be 2,000 sq. ft., or more. Service brakes of the shoe-type, which act automatically when the power supply to the driving motors is interrupted, cannot be relied upon to prevent skidding on iced or greasy rails and some mode of anchorage is required.

Manually-operated toggle-type rail clamps usually suffice for cranes of small capacity, but for large cranes automatic clamps are necessary, and the operation of these can be initiated by an anemometer. The circuit arrangements are such that (a) the rail clamps are set automatically when the crane is at rest, and (b) the travel motors cannot be energised until the clamps are released.

Such clamps usually consist of massive toothed jaws anchored to

Modern Dry Docks—continued

the sill girders of the crane pedestal and arranged so as to clamp firmly to the head of the rail. Set either by spring or weight, and released by motor, they function independently of the operator when the wind velocity exceeds the maximum safe operating value. Moreover, the controls are interlocked so that the clamps set automatically when the crane is at rest and release prior to switching-on the travel motors. Power failure, or anemometer interruption of the motor control circuits also sets the clamps. Adjustments are checked periodically by energising the travel motors and under this test, if the adjustments are correct, the crane should remain at rest.

A weight-operated clamp developed by the Westinghouse Co., combines two systems of braking. After hoisting the weight the squirrel-cage clamping motor is held at rest by means of a shoe brake. The latter is released on activating the clamp and dynamic braking provides a safe lowering speed even when the weight overhauls the motor.

In some instances land-side clamps cannot be fitted owing to the difficulty of providing a satisfactory design and, at the same time, of allowing a flush deck for vehicular traffic along the dock.

Mechanism.

Good design implies independent mounting of the hoisting winches, slewing and luffing mechanism, the machinery layout being such as to facilitate routine inspection and maintenance. Lifting tackle commanding the whole of the machinery and capable of lowering any item of equipment to ground level is necessary. When centralised lubrication is not provided, all lubricating nipples should be of similar type and readily accessible. In most instances the winch mechanism is of orthodox design, the motor driving the rope drum through a flexible coupling and enclosed treble-reduction spur gearing. An alternative is to have a worm gear as a first reduction. Drums of steel-plate welded construction are sometimes used in preference to cast iron. The drum of the holding brake can be conveniently combined with the coupling on the motor spindle, and the brake is usually designed to hold at rest a load 25 to 50 per cent. in excess of the rated hook load. Wire ropes are generally of 6/37 formation, made of 90/100-ton steel wire, and designed with a static factor of safety of 8. Sheaves of the self-oiling or roller-bearing type are superior to the bronze-bushed type, and safe access to the sheaves is a necessary requirement. Sometimes the main hoist consists of two hooks with duplicated mechanism arranged to give independent, combined or synchronised operation.

Conditional on the permissible tooth load being adjusted by a service factor to suit the duty of the motion, the basic strength and wear ratings determined in the manner described in B.S. 436: "Helical and straight spur gears" can be relied upon; but, pending overdue revision of the specification, it is advisable to adopt the material constants and speed factors given in B.S. 545 "Bevel gears." In the case of the main and auxiliary hoisting motions it is found convenient to determine the load on the drum wheel from the hook load and rope reeving, and to consider each reduction separately making due allowance for efficiency.

Of special interest is the layout of the main and auxiliary hoisting winches on a number of 45-ton jib cranes (Fig. 9) made by the M.A.N. Co., Nuremburg. Each motion is arranged as a two-motor drive in conjunction with a planetary gear as shown schematically in Fig. 10. Cases are infrequent in which both D.C. and A.C. motors are used for operating one motion, but the main hoists of these cranes furnish such an example. One of the motors, rated at 120 h.p. 465/1,390 r.p.m., is a D.C. machine with variable-voltage control geared to lift 45 tons at 26-ft. per min., and the speed of the motion can be increased progressively by field-weakening for hook loads less than 45 tons. Rated at 9 h.p., 950 r.p.m., the A.C. induction motor, used for spotting the load at a speed of 1.3-ft. per min., drives the sun pinion of the planetary gear through a 36 : 1 worm reducer not shown in the diagram (Fig. 10).

The auxiliary hoist induction motors are rated at 50 h.p. and 7 h.p., and the former is a two-speed machine designed to lift 5 tons at 122-ft. per min. and 2½ tons at 245-ft. per min. The 7 h.p. spotting motor drives the planetary gear through a multiple spur reducer and the hook speed is 2.3-ft. per min.

Characteristics of the two hoisting motions are summarised in Table 3.

TABLE 3. Hoisting Characteristics of 45/5-Ton Crane.

Motion	Hook load Tons	Hoisting speed Ft. per min.	Motors	Remarks
Main Hoist	45	26	120 h.p. at 465/1,390 r.p.m.	
	30	39		Field
	15	82	D.C. V-V control	weakening
	0 to 45	1.3	9 h.p. at 950 r.p.m. A.C.	Spotting
Auxiliary Hoist	5	122	50 h.p. at 725/1,460 r.p.m. A.C.	2 : 1 pole change
	2½	245		
	0 to 5	2.3	7 h.p. at 950 r.p.m. A.C.	Spotting

A typical slewing motion consists of a motor flexibly coupled to the first reduction followed by a gear train terminating in an overhung pinion in mesh with the slewing rack which is fixed to the substructure of the crane. The first reduction is usually a worm gear having a vertical output shaft, the latter being connected to the worm wheel by an adjustable slipping clutch to limit the torque. When a lantern wheel is used in preference to a spur rack, the locked steel pins should be readily removable. A shoe brake, operated by a pedal in the cabin, is fitted to the motion. For large cranes the slewing mechanism is often duplicated. In designing the slewing mechanism it is desirable to work backwards from the load on the rack. In computing this load the determining factors are the inertia of the revolving superstructure and its attachments, and wind-pressure effect.

Unlike slewing and hoisting there are numerous methods of luffing, and several of them have been illustrated above. As examples of the uncompensated methods may be cited rope- and screw-operated motions. Accurate load spotting and smooth operation characterise both and, when used for final lowering of the load into position, the motion is extremely sensitive. Although low-angle screws are said to be self-braking it is advisable to provide a small electro-mechanical brake on the motor spindle to counteract the effects of vibration. A novel screw-luffing gear, developed by Dravo Corporation, Pittsburgh, has been applied to a number of notable dry-dock cranes. It consists of a floating screw frame with the right- and left-hand screw engaging with articulated nuts, one of which is link-connected to the jib and the other to the

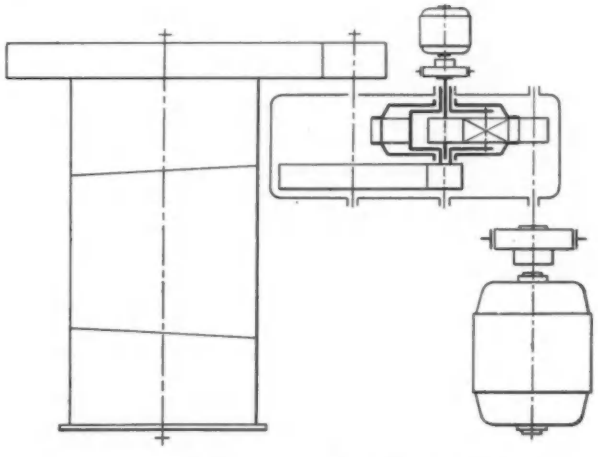


Fig. 10. Two-motor hoisting winch with planetary gear.

rear end of the revolving superstructure. The screw is rotated by a gear reduction and motor located centrally on the floating frame.

Representative of balanced level-luffing arrangements used by British crane makers are the "Toplis" system introduced by Stothert and Pitt, Ltd., and the Babcock and Wilcox system (Fig. 11). The distinctive feature of the latter is a jib constructed in two sections, the outermost of which, known as the arm, is folded in towards the other automatically as the load is luffed-in. On the

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Continent the screw-operated balanced level-luffing gear (shown in Fig. 3) has been applied to jib cranes of all sizes.

In cranes of this kind the projection of the folding lever permits the handling of bulky loads without danger of fouling the main jib, and the shortness of the jib allows the crane to operate freely in restricted spaces.

Reverting to the hoisting motion. Based on fitting-out crane experience, in a number of instances it has been found advantageous to provide a jigger hoist in addition to main and auxiliary hoists. Such jiggers rated at 5 to 15 tons are operable over a wide racking range varying from 30-ft. to 115-ft. radius.

Control.

Irrespective of the power supply, D.C. or A.C., slow-speed notches are desirable for each motion and, to minimise the duty of the mechanical brakes, controlled electric braking is necessary. These requirements are easily satisfied with D.C. supply systems but it is only in recent years that comparable methods of A.C. control have become available.

Of the four methods in common use for controlling a D.C. motor, rheostatic control, in one form or another, gives dependable service. Potentiometer control, with or without shunted-armature connection, is customary for the hoisting motions.

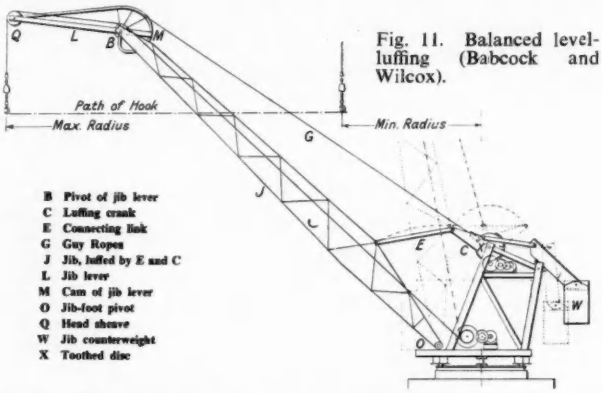


Fig. 11. Balanced level-luffing (Babcock and Wilcox).

Variable-voltage control, in various forms, is favoured when the utmost precision of movement is required. Field control is often used in conjunction with rheostatic and variable-voltage control to secure a wider speed range.

Amongst the numerous methods of control developed to suit the wound-rotor A.C. induction motor are: counter-torque; D.C. dynamic braking, known as D.C. injection; and unbalanced voltage. Some of these are combined with other methods, such as pole-changing, in order to obtain the required characteristics.

Control comparable to that of the variable-voltage D.C. system can be obtained by means of three-phase A.C. commutator motors and, as regards initial cost, there is little to choose between the two systems.

Contactor control is requisite for the main and auxiliary hoisting motors since these may be rated at 100 h.p. or more. Notwithstanding the fact that motor ratings for the other motions are often within the capacity of a manually-operated drum controller it is preferable to use contactor control throughout, not on account of greater reliability but chiefly owing to: (a) simplification of the main wiring; (b) ease of operation by means of a master switch connected in the control circuits; and (c) possibility of incorporating a number of desirable features such as automatic acceleration. The several master switches, located in the cabin, are preferably arranged for "sympathetic" operation and grouped so as to be within easy reach of the driver.

The driver's cabin should have a clear height of 6-ft. 9-in. and, in addition to being insulated, ventilated and heated, should afford the driver an unrestricted view of the load and as clear a view as possible of the surroundings. This requirement implies glazing at the front and sides.

The contactor controllers and associated resistors are located in the machinery house and the latter should be separate or sound-proof from the cabin so as to ensure that the noise does not confuse the driver.

In this country a driver's seat is a statutory obligation; but the driver, if he so wishes, is at liberty to stand when at work. Such a seat made of hard wood, shaped to fit the person and adjustable as to height, together with an adjustable back, is hygienic, durable and relatively inexpensive.

Feeding-back.

When electric braking is used for lowering a heavy load only a small amount of energy is required for excitation purposes and the armature, mechanically-driven by the overhauling load, develops surplus electrical energy which is fed back into the supply network or dissipated as heat in resistances. If a mercury-arc or other rectifier is used for supplying the crane or cranes, and for no other purpose, it is necessary to arrange for a ballast resistance to be connected across the D.C. busbars when energy is being returned to the line because the rectifier cannot convert D.C. input into A.C. output. Feeding-back conditions also prevail when a separate unit, such as a diesel-electric set, is used for powering one or more cranes. In some instances the ballast resistance is permanently connected across the busbars, but it is more economical to arrange for the resistance to be connected-in, as and when required, by means of a contactor which is operated either by the rise of busbar voltage during regeneration or by means of a centrifugal switch when the engine speed exceeds the normal by a predetermined amount. When cranes are to be powered from a rectifier, or from a diesel-electric set, it is advisable to inform the makers and to confer with the control-gear specialist.

Current Pick-up.

Current is supplied from the distributing network either by a flexible trailing cable from plug boxes, or by sliding collectors in contact with bare conductors located in a drained trench or subway in the dock wall.

Ground-type watertight plug connecting boxes do not impede traffic and are preferable to those of the pedestal type. Used in conjunction with low voltage A.C. or D.C. trailing cables, the drained boxes are fixed so that the bevelled lids project slightly above ground level to prevent surface water entering when the plug is inserted or withdrawn. To protect the circuit in the event of damage to the cable, the boxes are provided with high-rupturing-capacity fuses which also serve as isolators. The trailing cable, positioned in a groove along the track, is wound on a drum which is mounted on the substructure of the crane. The drum has enclosed collector rings and accessible finger contacts. Tension on the cable is maintained either by a spring or preferably by a sliding balanceweight geared to the drum, or by a torque motor the armature of which, when at rest, has sufficient resistance in series to prevent injury to the windings. Under these conditions the armature exerts a constant torque and the slack is taken up automatically when the cable is unwound.

Guarded conductors in the services subway are superior to a crane collector trench or trailing cable when considerable distances have to be traversed. In an ingenious collector system developed by the M.A.N. Co., the pick-up arm passes into the subway through a 3-in. slot which is kept covered on both sides of the crane by a wide steel strip to the underside of which is attached a wire rope running the full length of the track. At the pick-up point the strip is lifted, turned through a right angle and replaced by means of horizontal and vertical rollers attached to the undercarriage of the crane.

Improvements at Porto Amelia.

A new wharf with a quay length of 600-ft. for ocean-going ships and 435-ft. for coasters has been built at Porto Amelia, Mocambique. A transit shed with a capacity of 2,400 cu. metres is to be built and two additional sheds are contemplated and also a railway line. Tractors, trailers and mobile cranes will be provided when increased traffic warrants their use. The minimum depth of water at the quay for ocean vessels is 26-ft. and 16-ft. for coasters.

The Effects of Sea Water on Waterfront Structures

Part II. Design, Construction and Maintenance Recommendations

By LT. LLOYD E. STIFFLER, Jr., CEC, USN*

(Continued from page 182)

Experience has shown that, when design and construction techniques embodying adequate protective measures are used in the erection of marine works made of concrete, a relatively small amount of deterioration will be experienced. If these precautions are taken the structure will stand for its design life or longer with little maintenance necessary beyond that normally required of any concrete building.

Following is a list of design, construction, and maintenance recommendations and suggestions for use in coping with action of sea water on concrete:

1. The design specifies the concrete mix, the water-cement ratio, the admixtures used, the design stresses, the configuration of the individual members as well as the structure itself, and the determination of the amount of cover over the steel.

It is the responsibility of the engineer to specify a reasonable concrete mix.

Several prominent marine structure designers recommend that the stresses used for design of waterfront works be reduced from those normally approved by the various building codes. Figures of from 60 to 80 per cent. of normal have been recommended.

A good rule to follow in determining the location of bracing is to place it at least 1 foot above the spray or splash line, which may be several feet above the high-water level. If steel is to be used to fasten the bracing, place over it a protective cover of paint or bitumen to eliminate any chance of rusting, for if corrosion starts, it will be only a matter of time before the expanding oxides cause failure of the concrete. Actually it is considered better to eliminate bracing from the design entirely where soil conditions are favourable for the use of raker or batter piles to take the horizontal thrust. If the concrete is subjected to abrasion, squared or sharp corners should be omitted from the design. Protection of corners by means of surface setting of steel angles is not recommended.

To prevent or decrease the possibility of corrosion of reinforcing steel, the Bureau of Yards and Docks has established a standard for concrete at the water surface in which the steel should have a clear cover of concrete of at least 3 inches from a depth of 3 feet below low water to above the splash zone. The purpose is to protect the steel in the area where it is most vulnerable to attack.

In design of marine structures, it is better to have a concrete member as rigid as possible to meet the design standards so that during impact of either ships or waves there will be a minor amount of bending, with little or no tension cracks.

2. The concrete to be used on structures in contact with sea water should have well-graded aggregates, a low water-cement ratio, and a high cement content, making a rich mix—thereby providing a high-quality maximum density concrete. As is well known, the lowering of the water-cement ratio increases the strength of concrete and also increases the resistance of the product to deterioration by natural forces. The increased strength explains a part of this resistance, but consider in addition that excess water in concrete will take up space, and after it has evaporated voids will remain, resulting in a more porous material and making it vulnerable to sea-water action.

The Bureau of Reclamation recommends that the sand content be on the low side, with large well-rounded coarse aggregate for maximum protection. Others consider that mixing the mortar first and then combining it with the coarse aggregate will provide better results than the standard dry-mixing method. For the larger structures use the largest size coarse stone available that will meet the design specifications and thereby reduce the water-cement ratio and the amount of fines that can be attacked by sea water.

The water-cement ratio should be as low as practicable for placing the concrete. It has been shown by tests that six to six and one-half bags of cement per cubic yard of concrete mix will be suitable for average conditions of weathering, but a seven-bag or richer mix will be required for the more severe conditions.

3. So that the engineer could have a suitable concrete that would be stable in contact with sulfate-rich materials, the cement industry has developed cements that are practically nonreactive to sulfate soils and waters. For use where moderate resistance to sulfate action is required, the Type II cement has been devised with characteristics very similar to standard Type I in regard to setting time and soundness, but with a larger specific surface and a slower strength gaining curve until 28 days, when the strengths are equal. Type II requires a maximum tricalcium aluminate of 8 per cent. and a minimum of 21 per cent. silicon dioxide. It thereby reduces the materials reactive with the sulfates and establishes a minimum of the materials that react with the free lime formed during hydration to form a stable, nonsoluble compound.

4. Pozzolana cements (the cements used by the Romans and named after a town in Italy) are basically of volcanic origin, containing compounds of silicon, aluminium, and other elements. The Romans used pozzolana and hydrated lime to make a cement. Today the term "pozzolana" refers not only to the volcanic compounds but also to certain shales, trass, and blast furnace slags that are siliceous. These materials are mixed and ground with calcined limestone, but unlike portland cements they are not clinkered and reground. Pozzolanas have been recommended by most of the prominent waterfront engineers for use in marine structures in sufficient quantities to react with the free lime of hydration of the portland cement to form a rigid gel of monocalcium silicate that is not soluble in water and helps form a watertight seal.

Addition of portland cement to a pozzolana cement mixture will normally accelerate the setting, but will not decrease the resistance to sea-water action. Conversely, when pozzolanas are added to portland cement mixtures, the resistance to sulfate attack will be increased.

5. To improve the resisting qualities of concrete against sea water, considerable emphasis has been placed in recent years on the use of admixtures. Foremost among these is the one that entrains air. The Army Corps of Engineers has accomplished extensive research testing of the effects of sea water on concrete, with the results indicating that an air-entraining admixture with a good grade of concrete will give excellent results in lessening the effects of water attack.

Air entrainment increases resistance to the effects of salts. (This is important for concrete pavements in those areas where salt is used to melt snow and ice.) It also reduces water absorption properties of the concrete. Even where there is an excessive percentage of tricalcium aluminate in the cement, air entrainment improves the quality of the material.

An air entrainment of about 5 per cent. has been recommended for structures in contact with sea water. With a content of 10 per cent. or higher, the resistance of the concrete to abrasion is noticeably reduced. Addition of calcium chloride to air-entrained concrete for the purpose of a high-early set will not affect the beneficial results of the air entrainment if the calcium chloride content does not exceed 2 per cent.

6. In order to make concrete watertight, several port authorities have used a coating on the surface of hot or cold applications of tar or asphalt. The value of such coatings have not been proven over a long period of time.

7. The use of precast or prefabricated sections and members will permit proper and adequate curing, suitable control of construction, restriction of shrinkage, and application of protective coating.

8. The Army tests have not as yet indicated any definite tendencies relating to the curing of concrete and deteriorations, but

*The author prepared this paper, which first appeared in the Civil Engineering Corps Bulletin, when he was on duty under instruction with the Naval Reserve Officers Training Corps Unit, Princeton University. He wishes to acknowledge the assistance of VADM W. M. Angas, CEC, USN (Ret.), Dean of Princeton Engineering School.

The Effects of Sea Water—continued

there are several rules adhered to by waterfront engineers that should be included in the specifications of every job.

Concrete using a rapid curing agent or method should be carefully watched during the initial curing stages because of the abnormal heats of hydration that form and cause expansion cracks. During curing, keep the concrete moist; keep the direct rays of the sun away from the surface; avoid extremes in temperature, maintaining between 50° and 70° Fahrenheit if possible; keep the member in air until it has cured for approximately 6 weeks (some engineers recommend a curing period of from 60 days to 6 months); and do not load the structure or member until adequate strength characteristics are attained—which will be after 7 days for a Type II cement.

9. A common source of trouble in concrete work is the failure along the planes of contact of the successive lifts or pours, usually caused by inadequate bonding of the two surfaces of contact. It can be caused by poor workmanship or by the formation of a porous concrete on top of the lift due to water gain—a tendency of water to migrate toward the surface of freshly poured concrete. The use of a water or air blast to prepare the surface prior to the next pour, and the use of non-corrosive water stops at the joints, can do much to prevent this type of failure.

10. Honeycombing of concrete, especially where it will come into contact with sea water, can be disastrous to the permanence of the structure. It indicates a porous mix and probable separation of the aggregates during placing.

The Army tests have proved that the use of an absorptive form lining improves the durability of the concrete surface, which is contrary to the theory of the past that smooth, metallic, non-absorptive forms will give a protective surface, especially when vibrated. This change in theory is relatively easy to explain in that a decrease in water-cement ratio will increase strength and impermeability, whereas if the water were left at the form surface small void spaces would remain after the water evaporated.

11. Storing the reinforcing steel for a short period of time in the open prior to placing in the forms will assist in the removal of mill scale. Mill scale has a harmful effect on the bond between the steel and the concrete.

12. Avoid shocks in placing either fresh or set concrete to prevent separation during placing or formation of cracks after setting that may allow later infiltration of sea water. This raises the question of concrete piling: If the soil conditions permit, jetting of the pile would be the answer; otherwise care must be exercised during driving so that neither tension cracks nor crushing occurs.

13. After concrete in an existing structure has spalled away to the point where repairs are necessary, the method most recommended is the use of pressure concrete after a thorough cleaning of the old concrete and steel. The pressure concrete industry (known as Guniting) has grown in the United States since World War II so that in almost any locality there are well-trained operators capable of repairing structural members disintegrated and in need of rebuilding.

Following the above suggestions and recommendations can increase the quality of the finished product. But there is nothing that can replace the integrity and conscientiousness of the workers involved in its manufacture. Constant care and attention must be exercised if the concrete is to give the expected results. In order that a good, durable, watertight concrete may be obtained the designer and the construction engineer are equally responsible for using concrete commonsense.

Part III. Corrosion of Steel in Water

Defined as the wearing or eating away by chemical or electrical action, corrosion is familiar to everyone as the common ferrous oxide or rust. Corrosion of steel in sea water is substantially the same as corrosion of steel in air, but in water is usually much more rapid. Extensive research has been carried on in this country and in Europe, and a great deal of valuable information has been obtained. It has been found that the major cause of corrosion of steel in water is electrochemical, and that the secondary and tertiary causes are chemical microbiological.

The ore or oxide condition of a metal is its natural state; therefore, during its lifetime the metal is constantly attempting to revert back to this stable state. Mill scale found on structural steel as it comes from the mill is an oxide of iron and is one of the major contributing factors of corrosion.

Electrochemical action on steel requires two dissimilar metals and an electrolyte. These requirements are met when a steel members covered with mill scale is immersed in sea water, for the bare steel acts as the anode and the mill scale as the cathode, with the sea water as the electrolyte.

In other words, a simple basic battery has been formed. An electrical current is produced that tends to remove the metal from

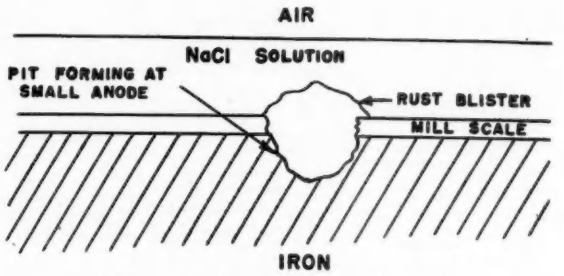


Fig. 1. Pitting at break in mill scale.

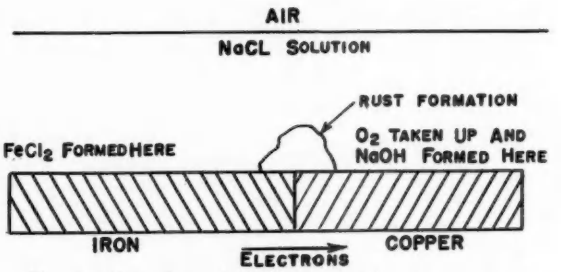


Fig. 2. Corrosion of dissimilar metals in sea water.

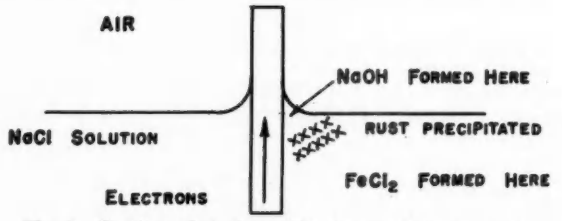


Fig. 3. Rusting of steel partially immersed in sea water.

the bare steel surface and deposit it at the anode in the form of sodium hydroxide (soda) and hydrogen. As the depth of the corrosion products increase, the rate of corrosion will also increase due to the increase in anodicity. It follows that localized corrosion areas or pits are formed at the edge of the larger mill scale masses.

Electrochemical action is not limited to mill-scale and bare-steel areas, but will be found wherever two dissimilar metals are in contact or close to each other and surrounded by an electrolyte.

The formation of the hydrogen product tends to reduce the rate of electrochemical corrosion. Hydrogen requires free oxygen with which to combine; therefore the rate of corrosion is proportional to the amount of free oxygen available. This is known as the oxygen absorption type of corrosion. Under average conditions the deeper the steel is placed in the water the less free oxygen is available and the less the corrosion. Steel also tends to rust less in alkaline or basic water than in water that is acidic.

It was stated above that the formation of hydrogen tended to reduce the rate of corrosion. This is true unless anaerobic bacteria is present in the silt or mud into which the steel has been placed. As long as there are sufficient organic materials for food

The Effects of Sea Water—continued

and hydrogen produced by galvanic action, this bacteria will produce sulfides from the surrounding sulfates in the water, with the result that the sulfides will attack the steel. This feature will be of interest to personnel in charge of ships or barges of steel that are moored so that they rest on the bottom during low tides —during which time they are highly susceptible to the action of the anaerobic bacteria.

The Army Beach Erosion Board and the International Nickel Co., in separate tests over long periods of time, have produced results showing the rates of corrosion on steel piling exposed to sea water. These results are shown graphically (Fig. 4). They present an interesting conception regarding the areas of maximum corrosion. The corrosion in area (E), although not the greatest is the most difficult to prevent.

These tests do not include the electrochemical effects normally encountered in standard structures. It is usually within the tidal range that the electrolyte (sea water) is most rich in free oxygen. Therefore, the area usually corroded to the greatest extent is in the range of the tides.

Finally, steel in sea water can be worn away by abrasion of sand or gravel carried by the tides, waves or currents. In some

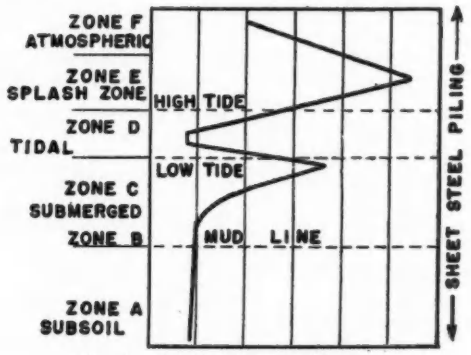


Fig. 4. Relative loss in thickness.

locations heavy steel piling has been worn away within a period of a little over 1 year. A different concept about abrasion on steel is that the abrasion materials do not actually cut away the steel itself, but remove the rust to bare metal exposing the steel to accelerated attack.

Corrective Measures

No attempt will be made to discuss the corrosion of steel in air other than that which is in the splash zone. In air electrochemical action is not considered to be a cause of corrosion. The methods of protecting steel in air are similar to those used in protection of immersed steel, with the obvious exception of the use of cathodic protection.

1. The most accepted method for the prevention of corrosion of steel placed under water is the use of cathodic protection. This can be utilized only when the metal to be protected is in contact with an electrical conductor such as water or moist soil. It is relatively inexpensive when effectively used. Basically, this type of protection consists of inducing an opposite current of equal intensity to that created within the metals by the electrochemical action, thereby counteracting any corrosive tendencies.

When designing, it is logical to carry out a cost study based on the expected life with cathodic protection, the expected life without cathodic protection, the replacement cost of individual members that may fail, and the cost of a heavier section designed for a longer effective life. It may be that the cost of cathodic protection would be more than the extra cost of increasing the effective life of the structure by the use of heavier and thicker structural members.

2. Metallurgists have developed corrosion-resistant metals, but unfortunately the producers of these metals have not found a way to reduce the costs of manufacture to a price range where they can be extensively used. The majority of metals that are rust resisting in air do not have the same capabilities in sea water; most of these metals depend on their protective oxides to resist corrosion. When immersed in sea water the metal is screened from oxygen, such as when the surface is covered by marine growth and oxides cannot form.

3. The most extensively used method of protection for steel in sea water is by means of a protective coating, either metallic or non-metallic:

Metallic: All metals that are used as protective coating for a structure should be anodic to steel or the base metal; otherwise electrochemical action will take place and will result in the formation of hydrogen on the surface of a member that will allow the steel to corrode at a more rapid rather than a slow rate.

Non-metallic: Non-metallic coatings are the most widely used methods of protection of waterfront structures. Even when steel is coated with metallic protection, the majority of harbour engineers specify non-metallic coatings as well. In order that any protective coating can satisfactorily adhere to the surface of the steel and give a long life expectancy, the surface must be cleaned. The degree of cleaning will determine the useful life of the protection. The selection of the method used will depend upon the cost, length of service desired, environment and climate, opportunity for repairing, funds available, and shop facilities.

Recommendations

A great number of schemes and arrangements have been tried and discarded, but there have been many that have given good results. Following is a list of a few of the successful ideas proven in practice by waterfront and corrosion engineers:

(*a*) Do not underestimate the effect of loss of material from steel members due to corrosion.

A study was made in Boston Harbour on a 14 WF 73 **H**-pile with an unsupported length of 48 feet as to how loss of material would affect its load-bearing capacities. The member was placed in sea water, and normal deterioration about the edges of the flanges progressed until about 10 per cent. of the gross area was lost. An analysis was made of the remaining section and it was found that the load-carrying capacity was reduced by 44 per cent. This reduction was caused by the decreased radius of gyration, in addition to the reduced area.

(*b*) When designing a pier or similar structure, it is recommended that the bracing be placed not only above the high tide level, but also above the splash line. In choppy water a 1-foot clearance is not usually sufficient. Bracing is particularly susceptible to corrosion because of its many crevices that are hard to reach for maintenance, particularly where it joins the piling or decking.

(*c*) Exposure to salt spray greatly increases that rate of corrosion. Where practicable, locate the structure in such a position where it will receive as little sea spray as possible.

(*d*) For certain types of structural members an increase in the thickness of the section will greatly increase its lift expectancy. It takes close to a century for pitting alone to penetrate 1 inch of bare mild steel.

The life of sheet piling depends upon the original thickness of the steel, the rate of loss of the thickness, and the thickness of the piling when the structure is no longer useful because of loss of metal. All other variables being equal for any one particular area, the deciding factor for useful life is the original thickness.

(*e*) In slow moving (less than 4 mph) or stagnant water, marine growth will usually form in a heavy layer, causing a slight retardation to the rate of corrosion because of the exclusion of oxygen. Barnacles, though, will cause blistering of the painted surface with subsequent breaking through of the paint, exposing the bare metal. The steel will then become an anode, with the electrolytic current flowing through the body of the barnacle causing rapid deterioration at that point.

Therefore, where paint is used it is recommended that the formation of barnacles be prevented. Antifouling paints could be used. Cathodic protection is another solution to this problem.

(*f*) The Army tests have shown that where steel is exposed to water, the use of either a sand or earth cover reduces the rate of corrosion. When both sides of the structure are completely covered, the rate of loss of material is negligible.

The Effects of Sea Water—continued

(*g*) Paint is no protection against abrasion. For paint to be useful where abrasion is present, the paint must be protected by concrete, wood planks, or steel cylinders.

(*h*) Where feasible, steel can be given a coating of concrete for protection against abrasive forces and to lessen corrosion tendencies. One California engineer recommends the following for steel **H**-piles:

(1) Thoroughly clean the steel; wash, and paint with two coats of asphalt emulsion, each coat to be one-sixteenth inch in thickness.

(2) Drive the piles and then drive a steel cylinder around each pile. Jet the inside clean of sand and fill the void with cement grout. Using this method, the piling will last for 50 years or longer. Steel **H**-piles driven in the same location by standard methods and with no protection will require replacement in about 5 years. This method is recommended where severe abrasion exists.

(*i*) Whenever piles are placed in a location where abrasion is to be expected, the use of cylindrical or pipe piles is recommended. Maintain a distance between piles of at least five diameters to reduce the tendencies of the water to form eddies. Where severe abrasion results an additional sleeve at the scour line will increase the life of the member. **H**-piles oriented so that the web is normal to the breaker line will show signs of excessive wear.

(*j*) Where protection by concrete coating or cylinders is not adaptable or within the allotted funds, then pieces of 2-inch-thick wooden planking can be strapped around the steel members, increasing the life of the member by 200 per cent. or more.

(*k*) When abrasion due to sand or gravel has worn away a member, a measure of protection can be obtained by fastening on the surface of the old structure a steel wearing plate. As the wearing plate becomes useless it can be readily replaced, thereby prolonging the life of the structure for years.

(*l*) Some German engineers have recommended the use of a spray coat of zinc on steel and then subsequent painting with two coats of a good paint or bitumen. They have estimated that the decrease in future maintenance will more than compensate for the increased initial costs.

(*m*) The English Institute of Civil Engineers has recommended for all structures of steel to be erected in sea water that the material be first cleaned, then given multiple coatings of paint, preferably iron oxides, thinly applied and well brushed, using at least four coats. The result will be a long-lasting, dependable, protective coating.

(*n*) When paint is used as the protective covering it should be applied when the air temperature is above 50° Fahrenheit, and as soon as possible after the metal has been cleaned. The best method is to dry the paint in a special paint-drying booth, but under average conditions select days when the air is as dry as possible.

(*o*) Paint mixed with silica sand and ground glass has been tried by the Army for combating barnacles, with good results.

(*p*) Painting initially and/or at irregular intervals will materially reduce the rate of corrosion.

(*q*) Felt wrapping coated or saturated with coal tar will give temporary protection against corrosion.

Conclusions

The foregoing discussion is not the answer to the problem of deterioration, but merely a review of the past work and experiences. The final answers that will establish the best methods and materials have not yet been obtained. Many additional factors will have to be added to the fund of knowledge before positive corrective measures will be known.

Corrosion, deteriorations, disintegration, and abrasion do not follow the same patterns in all parts of the world, so that when designing and constructing a new structure or maintaining a present facility, each project's corrosion and deterioration problems should be studied as separate subjects based on local conditions.

Before protective measures are planned and executed, the economical justification should be consistent with the planned life expectancy of the structure. Do not be frightened off if the initial costs of protection look excessive, for with proper design it will be found that the savings in maintenance costs will justify the added expenditures.

The design of a structure is most important. The designer can make the structure open, clean, and free of corrosion traps. Or he can make it a maintenance supervisor's nightmare. Each engineer who deals with marine structures has within his control the ability to provide a good usable structure where maintenance problems of corrosion and deterioration are either eliminated or are negligible.

New Hamburg Transit Sheds

Experiments with Floor Surfacing

By JOHN GRINDROD, B.A. (Com.).

With the rebuilding of the Port of Hamburg, modernised distribution facilities have been incorporated into what is known as the "Hamburg Quay Layout." Special attention has been given to the adaptation of traffic areas on the quay and transit warehouses to present-day developments.

When planning the length of transit sheds at Hamburg a multiple of the length of a standard cargo ship is now customary, a length of about 300 m. being equivalent to two berths. It is thought that the width of a shed can only be gauged from experience although it is considered that a shed should be of width adequate enough to permit the handling, over the length of a berth, of that part of the ship's cargo destined for the shed and to store this cargo, ready sorted for the consignees. Further, it should be wide enough to allow for the warehousing of a limited amount of cargo remnants, not required immediately by the consignee; to allow for the assembly of export cargo to be loaded by the ship after discharging; and to permit certain manipulation of both import and export cargo.

In Hamburg, experience has shown that the established width of 50 m. is still adequate for standard cargo ships of 10,000 to 12,000 tons gross and sheds are still being built as one-storey structures since the handling of cargo in every second storey is believed to lead to an increase in cost of at least 25 per cent. The large extension of the port of Hamburg has led to the separation of transit sheds and warehouses, the latter not having been considered in the quay lay-out. If imported goods cannot be shipped to the consignee within a fixed time they are transferred to special warehousing facilities at other locations in the port.

In the transit sheds, good lighting and roomy storage areas facilitate, cheapen and speed up the work, loads being spread out at low level only, though these facilities involve high investment charges. Experience has shown that for sheds of 50 m. in width a first-class natural lighting can only be obtained, without having recourse to expensive skylights, by continual bands of fenestration, 4 m. high, on the longitudinal walls (see Fig. 4). Ventilators are provided to avoid excessive heating by the sun's rays in the summer.

Up to 1945, shed floors in the port of Hamburg were made, almost exclusively, of fir planks, 5 to 7 cm. thickness (with alleyways of hardwood) supported by oak longitudinals on sand bedding. This surfacing has given extremely good results, since it is warm, dust-free, does not exude moisture and does not absorb the smell of merchandise. The latter is an important factor in view of the diverse nature of the ever changing pattern of goods and the sensitiveness of certain tropical products to alien smells.

Since 1945, the lack of timber has necessitated the use of concrete slabs, with or without asphalt surfacing. These floors have been unsatisfactory, however, since this kind of flooring tends to exude moisture and to absorb the smell of stored commodities. To overcome this, many goods are stored on timber gratings, although this increases investment and operation expenses. The development of dust by concrete is also detrimental in respect of certain goods. For these reasons Hamburg reverted to the use of timber

New Hamburg Transit Sheds—continued

(Top left). Coarse concrete rubble placed on sand fill (compacted by roller). **(Top right).** In foreground, fine broken stone placed on top of coarse concrete rubble and compacted by roller. In background, medium broken stone or concrete rubble placed on top of fine stone and compacted by roller. **(Bottom left).** In centre, mixture of fine broken stone and bitumen placed on top of medium broken stone and compacted by roller. At left upper corner, latex poured on top of bitumen-stone mixed and smoothed by trowel. **(Bottom right).** The finished surface.

floors as soon as this material became available again. Because of the increase in German timber prices, however, experiments are being undertaken to develop a shed floor surface of similar usefulness using other materials. One of the materials being tested is "Latexfalt" for the placing of which the sand bedding of the shed was compacted by interior vibrators and then a layer of stone debris placed and rolled by a 12-ton steam roller. On the top of this a 3 cm. thick layer of stone ballast was applied and rolled. The "Latexfalt" surfacing was spread 5 cm. high in three different layers, the 3 cm. bottom layer consisting of ½ part cement, 2 parts "Latexfalt," 3 parts Elbe sand and 9 parts aggregate 18/25; the 1½ cm. high second layer consisting of 1 part cement, 2 parts "Latexfalt," 2 parts Elbe sand and 5 parts aggregate 8/15; while the top ½ cm. layer consisted of 1 part cement, 2 parts "Latexfalt," 2 parts Elbe sand and 4 parts aggregate 3/8. All the layers were then compacted by a 12-ton steam roller.

Electrically driven four-wheel trucks of 1 ton to 2 tons capacity and electrically driven tractors, both of which often draw several trailers, have been used for the conveyance of general cargo between the quayside crane and the point of storage within the shed. Larger, unwieldy parcels have been transported by mobile shed cranes of 1 ton to 2 tons capacity. Fork-lift trucks and pallets have, however, been introduced in new transit sheds, the fork being replaceable by other appliances to meet special needs, e.g. the hydraulic clamp, which is applied sideways to such cargo as bales, etc.

Ten of the transit sheds at Hamburg, with a total area of 89,000 sq. m., are now air conditioned for the handling of tropical fruit, and more such facilities are likely to be added, since, with the establishment of a new record with more than 500,000 tons of tropical fruit imported during 1954, the port claims to lead other fruit importing ports in northern Europe. To give adequate insulation in such sheds the glazing is double and tarpaulins behind the shed doors add to the efficiency of the gas heating. Heating by low pressure steam in various air heaters has also proved satisfactory, the heaters being arranged along the walls of the sheds on a special gallery, and the air rotation blowers being so built as to serve as ventilators for the renewal of air.

The handling of fruit from ship to shed is effected by the usual quayside crane, and, in the case of bananas, by specially constructed elevators which deliver via conveyor belts directly onto railway wagons which run into the shed.

Refrigerated warehouses have usually been built to meet the needs of special commodities, such as herrings, frozen or chilled meat, Chinese eggs, etc., but they can be used for any type of refrigerated cargo.

New Ship Repair Berth at Sunderland

It has recently been announced that a new deepwater berth and quay 850-ft. long is to be constructed at the north dock, Sunderland, for Messrs. T. W. Greenwell and Co. Ltd., ship repairers. The quay, which will be capable of accommodating simultaneously two of the largest tankers, will be constructed diagonally across the north dock. The present entrance to the dock is to be closed and a new one, 200-ft. wide will be cut through the south wall of the dock and the dredged berth will have a draught of 23-ft. at mean L.W.O.S.T. The consulting engineers for the work are Sir Wm. Halcrow and Partners.

British Waterways Development Plan

The final programmes under the British Transport Commission's £5½ millions Development Plan have recently been announced. These concern the projected improvements to be undertaken on the Weaver Navigation in the North Western Division and on the Grand Union Canal between London and Berkhamsted.

THE WEAVER NAVIGATION

The improvements planned for the Weaver Navigation, costing over £260,000, are designed to enable this short but important water route to cater for the increasing use of sea-going vessels. Well over half-a-million tons of traffic a year is carried on the Weaver Navigation, which comprises the Weston Canal and the River Weaver, and which links the industrial centre of Winsford and Northwich with the Manchester Ship Canal and the River Mersey. The programmes includes bank protection and navigation works, £126,800; mechanisation of locks and sluice improvements, £33,100; dredging plant, £64,000; workshops and other premises, £36,900.

Bank Protection and Navigation Works.

Considerable bank protection work has already been carried out on the River Weaver where the natural banks are liable to erosion; the work to be undertaken will complete the protection on both banks of the waterway to safeguard them from the wash of the larger powered craft and coasting vessels now using the Navigation.

The towing path side of the Weston Canal, constructed in 1827, was originally protected with sandstone walling, which has deteriorated; this is to be reconstructed and raised where necessary, and at the same time protection work will be carried out on the opposite bank.

The worst of the bends on the waterway, which follows the course of the River Weaver, have already been improved, but a number of the remaining bends are difficult to negotiate for larger vessels. To ease these bends, re-alignment work is to be carried out at Bye-Flats, Saltersford, and Acton Bridge (all between Northwich and Acton Bridge); at Dutton; and at Vyrnwy Aqueduct and Catten Hall (both near Kingsley). A diversionary channel is to be constructed to avoid the disused Sutton Locks, whose structure is an obstacle to navigation, and which forms a silt trap requiring constant dredging.

As coasting vessels are unable to turn in the Weston Canal without proceeding to Weston Point (near Runcorn) a triangular piece of land adjacent to the waterway, between Marsh Lock and Weston Point, is to be dredged out to form a turning area for the vessels.

Mechanisation of Locks, and Sluice Improvements.

To speed up operations, the locks at Dutton and Saltersford are to be mechanised to enable the lock gates and sluices to be operated simultaneously from a central point; this will also eliminate the heavy manual labour now involved. At Saltersford an additional sluice is to be provided to improve the flood flow of the river through Northwich.

Dredging Plant.

Considerable dredging operations have to be undertaken on the Weaver Navigation, owing to the sand and silt which is brought down by a tributary, the River Dane, which joins the Weaver at Northwich. To increase the efficiency of the dredging plant, a new 200-ton diesel powered hopper barge is to be provided, and three existing steam powered barges are to be converted to diesel propulsion.

Workshops and Other Premises.

At Northwich Repair Yard, the main centre on the Navigation for the inspection and repair of larger craft, the main workshops are to be extended, and essential repairs are to be carried out to the dry dock. A heavy duty mobile crane is to be provided.

The Weaver Navigation.

The Weaver Navigation extends from its junction with the Mersey at Weston Point for 20 miles to Winsford, in Mid-Cheshire, and passes through the industrial part of Cheshire with various works, chiefly chemical and salt, established on its banks whose products for export form its principal traffic. At Weston Point, docks have been developed to which vessels measuring up to 240-ft. in length and carrying up to 1,700 tons can navigate.

At Weston Point two connections are provided with the Manchester Ship Canal, one for coastal vessels and one for barges. Connection is also provided with the Bridgewater Navigation for 70-ton barges by a branch canal, and at Weston Marsh there is a further link with the Manchester Ship Canal for vessels up to 800 tons. At Anderton an electric boat lift gives access to the Trent and Mersey Canal.

The progressive development of the Navigation to provide larger and better facilities has been continuous; bends have been removed and narrow lengths widened during the past 20 years so that it is to-day navigable throughout its length by 400-ton coastal vessels and 450-ton barges, compared with 200-ton coasters and 250-ton barges in 1930-1935.

THE GRAND UNION CANAL

The improvements which are to be undertaken on the London-Berkhamsted section of the Grand Union Canal mainly comprises: bank protection, £925,000; construction and enlargement of locks on tidal section at Brentford, £230,000; dredging and dredging plant, £180,000; miscellaneous works (installation of weirs, lowering of lock sills, widening under bridges, etc.), £64,000.

Bank Protection.

Between Brentford and Uxbridge, on the main route of the canal, and between Bull's Bridge Junction (Southall) and Harlesden, on the Paddington arm, some 13 miles of steel piling and 8 miles of concrete piling are required. Bank protection is also to be given to short lengths at various points on other sections. To meet the increased demand for concrete piles a pile-making workshop is to be set up at Bull's Bridge, augmenting the existing workshop at Narsworth, near Tring.

Tidal Section at Brentford.

Thames Lock, Brentford, which limits craft entering the canal from the Thames via Brentford Creek to 100 tons capacity and is a serious handicap to London lighterage firms who normally operate standard Lee-type barges of 135 tons, is to be replaced by two larger locks, each 95-ft. long and 18-ft. 6-in. wide, capable of taking a fully laden 135-ton Lee barge. The same difficulty exists at the double Brentford Locks, above Thames Lock, and one of these double locks is similarly to be replaced. These improvements, together with bank protection work already completed on Brentford Creek, will enable the large Lee-type barges to reach the wharves, warehouses and transhipping sites at the Brentford Depot, also the privately-owned wharves adjoining.

Dredging and Dredging Plant.

An extensive dredging programme is to be carried out so that all craft can carry at least 90 tons up to Berkhamsted.

Tn enable this work to be carried out, the existing dredging fleet is to be augmented by one new dredging unit (1 dredger, 1 tug and 6 happers) and 11 steel hoppers.

Miscellaneous Works

Certain lock sills and culverts between Brentford and Berkhamsted are to be lowered to the new standard depth, and in the same stretch the waterway under certain bridges is to be widened and deepened. The difficult entrance at the junction of the canal with the Paddington Arm at Bull's Bridge is to be improved by re-siting the towing path bridge.

The Grand Union Canal.

The Grand Union Canal, besides providing facilities for lighterage traffic in the London and adjoining areas, forms the main route from the Thames estuary to Birmingham and the Midland canals. It joins the Thames at two points, Brentford and Regent's Canal Dock, the distance to Birmingham being 134 miles by the former entrance and 150 miles by the latter. In the London area the route from Bull's Bridge Junction, Southall, passes through the industrial area of west and north London and thence by the Regent's Canal to Regent's Canal Dock, Stepney. There is also a connection between the Regent's Canal and the Lee Navigation by way of the Hertford Union Canal At Baunston (near Daventry) there are junctions for Coventry and the Warwickshire collieries and southwards through Banbury to Oxford.

The Dry Docks of America

Naval and Private Interests Favour Different Systems

By L. H. POWELL

In the July issue of "The Dock and Harbour Authority" there was published an article on Modern Dry Docks and an analysis of their design, construction and equipment. This month attention will be directed to the dry dock situation in the United States and the considerations which have led to the acceptance of different systems by naval and private industry.

Briefly, it may be said that in the United States the authorities responsible for naval shipyards favour graving docks, while sectional floating dry docks are the choice of the shipyards. The Todd Shipyards Corporation may be regarded as representative of the drydocking industry of America and Mr. Francis J. Smyth, the vice-president, puts the issue quite clearly.

"Of the two types," he says, "the floating dock is generally less expensive to construct, but is more expensive to maintain. Its berth has to be dredged at longer or shorter intervals, depending upon the rate of silting in the vicinity. As a rule, a graving dock requires more pumping, but electrical power is inexpensive; a floating dock needs more of a crew to man the valves.

"The great advantage of a floating dock to a commercial operation is its mobility. If business falls off in one location, the dock can be moved to a more promising site. A graving dock is a fixture. A floating dock is more adaptable. In docking a large vessel one or more of the dock sections can be added."

Of the 33 docks of the Todd Shipyards Corporation, which are located on the Atlantic, Pacific, Gulf and Caribbean coasts, only two are graving docks, and both of these are in New York harbour.

CHARACTERISTICS OF U.S. FLOATING DRYDOCKS AND GRAVING DOCKS

Brooklyn	Overall length ft.	in	Length over pontoons ft.	in.	Inside width at keel block height ft.	in.	Lifting capacity tons
Graving Dock ...	731	2	—		93	0	—
" " ...	573	3	—		46	0	—
Floating Dock ...	468	0	408	0	83	7	8,425
" " ...	552	0	492	0	91	8	16,000
" " ...	458	10	408	10	85	0	10,000
" " ...	622	0	552	0	96	0	20,000
Hoboken							
Floating Dock ...	180	0	130	0	50	0	1,112
" " ...	190	0	130	0	48	7	1,300
" " ...	330	0	250	0	72	7	4,700
" " ...	493	1	433	9	86	9	10,500
" " ...	182	4	132	1	53	6	1,050
" " ...	236	2	176	2	63	3	1,800
" " ...	228	0	168	0	61	0	1,655
" " ...	170	8½	120	8½	44	7	720
" " ...	657	3	587	3	100	0	22,000
" " ..	559	0	489	0	100	0	19,000
Galveston							
Floating Dock ...	523	3	462	3	84	8	10,000
" " ...	523	3	462	3	84	8	10,000
" " ...	614	0	544	0	90	0	15,000
" " ...	240	0	200	0	48	3	1,500
Houston							
Floating Dock ...	558	0	488	0	85	9	12,000
New Orleans							
Floating Dock ...	548	4	498	4	88	0	12,500
" " ...	614	0	544	0	90	0	15,000
" " ...	622	0	552	0	96	0	20,000
" " ...	350	0	298	0	64	6	3,700
Los Angeles (San Pedro)							
Floating Dock ...	541	0	491	0	88	0	9,000
" " ...	598	0	528	0	90	0	16,500
San Francisco (Alameda)							
Floating Dock ...	598	0	528	0	90	0	16,500
" " ...	542	0	472	0	86	0	11,500
Seattle							
Floating Dock ...	622	0	552	0	96	0	20,000
" " ...	412	0	352	0	67	7	5,700
" " ...	531	0	459	0	94	0	14,000
" " ...	531	0	459	0	94	2	15,000

The adaptability claimed for the floating dock is illustrated by the enlargement of the No. 10 drydock at Hoboken. From its previous dimensions of 657-ft. 3-in. length, 100-ft. inside width at keel block height and lifting capacity of 22,000 tons, this dock can be and has been enlarged to 755-ft. 6-in. long and to 25,000 tons lifting capacity. With the advantage of having two large docks, of universal sections, moored abreast of each other in the same slip, the engineers have designed a procedure whereby a section from one dock can be readily transferred to the other and in a matter of hours become an integrated part of the dock so enlarged.

The table given above, if compared with that given in the July issue relating to British drydocks, will show that the latter are usually longer and wider than the floating docks of the United States and that there are several exceeding the dimensions of the enlarged No. 10 Hoboken dock. However, it may be that the Todd Corporation have not been yet called upon for a dock bigger than the dimensions quoted. In any event, the ingenuity with which American drydock owners are dealing with the requirements of super-tankers, passenger liners and the larger cargo ships is an interesting sidelight on American methods.

It is not long ago since particulars were announced of a "floating dry-dock-cargo ship" ordered for Arctic service by the Federal Maritime Administration on behalf of the United States Navy. The primary task of this ship is the replenishment of Arctic military bases, but by opening a "gate" at the stern, the interior can be flooded to launch or retrieve landing craft. In operation it is reported, the ship will function much like a hull sawn in half, partially submerged, with small boats cruising in and out of the flooded area between the wing walls of the mother ship. To launch her craft, the ship will ballast down, flood the dock area and open her tailgate.

While not strictly a floating dry-dock, the construction of such a vessel, which has been specially designed under the supervision of the Bureau of Ships of the Navy Contract Department, is a refreshing reminder that departure from accepted practice presents no problems to the American mind.

New Crane Servicing Facilities at Southampton Docks

The British Transport Commission recently announced that the crane and outdoor machinery section of the Southampton Docks Mechanical and Electrical Engineer, who is responsible for the maintenance and repair of all dockside cranes and mechanical equipment, has recently moved from the old depôt at berth 27 to new and commodious premises at the north end of berth 45. Ocean Dock.

The new buildings, in red brick and continuous glazed walls, form a handsome and compact block, comprising the main garage and crane servicing bay, fitter's, electricians' and riggers' shops, mess room and offices.

The east side of the main block is occupied by the crane garage and servicing bay, access to which from the outside is by large sliding doors. A through rail track from the nearby shunting ground spans the length of the bay, enabling the rail travelling diesel

View of the new buildings. The larger block on the right houses the crane garage, servicing bay and workshops, whilst the smaller block on the left contains the mess room and offices.

New Crane Servicing Facilities at Southampton Docks—continued

The garage and servicing bay. On the left is the 10-ton diesel-electric rail travelling crane and in the foreground is a 5-ton mobile petrol-electric crane.

cranes to run in. There is an inspection pit for the rail cranes and also one for the petrol-electric mobile cranes.

Adjacent to the main bay there is a fitter's shop with modern drilling machines and other up-to-date equipment; a store with metal racking for tools and spares; an electricians' shop and a riggers' store where crane wires are spliced and stored.

At the north end of the building is a spacious mess room with seating for eighty at formica-topped tables and an electric cooker and hot plate where men can prepare their food. This mess room also acts as an assembly point for the crane drivers and mechanics and a sliding hatch connects it to the crane office where the men are allocated to their respective jobs. The assembly point is manned for the twenty-four hours for emergency purposes.

Flanking the corridor leading to the mess room is a locker room, where each man has a metal locker for clothes and personal belongings; a room for drying clothes and a boiler room containing an oil-fired boiler for heating the building.

On the opposite side of the corridor are offices for the Engineering Assistant in charge of cranes and outdoor machinery, crane foreman and general office, where the crane allocations are made. All the offices and shops are inter-connected by an internal telephone system.

The electrical load in the building amounts to 60 kw., of which 20 kw. is used for lighting, 30 for cooking and the balance for the machine tools and the automatic equipment associated with the heating plant. In the mess, assembly area and offices, lighting fittings of contemporary design are employed to harmonise with the general appearance of the premises, whilst in the workshops and garage industrial fittings suitable to the nature of the work are used. The standard of illumination throughout is high and care has been taken to keep the contrast level low so as to reduce fatigue during the hours of darkness. The whole of the electrical layout was designed and installed by the Docks Mechanical and Electrical Engineer.

Surrounding the main building is a wide concrete-surfaced yard and the whole of the premises are neatly enclosed by a 7-ft. high brick wall. The entrance gates on the east and west sides are of the upper and lower triangular leaf pattern, made of tubular frames and wire mesh, the first of this type to be used in the Docks.

The building has been designed to take another storey and for extension some 30-ft. to the northward.

These modern and well-equipped premises, which were designed and constructed under the supervision of the Docks Engineer in collaboration with the Docks Mechanical and Electrical Engineer, should greatly assist the important work of maintaining and servicing the cranes and mechanical equipment of the Docks.

Rapid Setting Mixes for Sea Defence Work

Development of New Product Impervious to Water

The problems arising from erosion and flooding, both along the sea shore and inland waterways, are a constant and costly worry to the Authorities concerned. For a number of years hot poured bitumen/sand and bitumen/sand/asbestos fibre mixes were used for sealing the joints between stone or concrete block revetments and for grouting random stone. As these mixtures had to be used not only between high and low water marks but also below water, the numerous advantages to be obtained from the use of a cold applied binder were apparent, if a suitable one could be evolved. Such a product would at once obviate the cost of drying sand and heating bitumen in cumbersome plant, generally in exposed positions; pouring a thermo-setting mix which cooled rapidly in cold winds when being carried between the mixer and the point of application; delays occasioned by the time of heating and mixing, especially in inclement weather, and finally, the inevitable difficulty in obtaining good adhesion between a hot mix compound and cold, almost certainly damp if not wet, slabs of stone.

The firm of Messrs. Smid and Hollander of Hoogkerk, Holland, made a detailed study of the conditions under which these mixes must be prepared and applied. It was found that the basic requirements which had to be fulfilled were as follows:—

(a) The mixes had to be prepared using apparatus—such as concrete mixers—which is generally available to contractors.
(b) The mixes had to set rapidly in order to avoid destruction by the action of waves or the incoming tide.
(c) After final hardening, it was essential that the product must exhibit durability against the attack of water and weather.

It was also apparent to Messrs. Smid and Hollander that none of the asphaltic emulsions then available could be used for this class of work. Stable and semi-stable emulsions do allow production of the dense graded type of mixtures required but mixes prepared from them need a period of many hours, or even days, to set.

Only an asphalt emulsion showing a high mixing stability but also able to break rapidly after the completion of mixing, would be suitable. It was therefore necessary to incorporate in the mixtures of emulsion and mineral aggregates additional agents which, without interfering in the mixing processes, would give rise to reaction which would be able to break up the emulsion system and accelerate setting; the complete process required to be independent of the evaporation of any water incorporated into the emulsions.

The method evolved by Messrs. Smid and Hollander was an electrolitic process capable of coagulating the emulsions and producing at the same time a crystallised, water insoluble, product

Eshalite has been poured at high tide below water into random stone via the tube shown. The tide has fallen leaving the Eshalite concrete grout, on which two white stones have been thrown, quite unaffected. The sea can be observed still covering the grout on the left.

Rapid Setting Mixes for Sea Defence Work—*continued*

which, in combination with the liberated asphalt, exhibited excellent bonding properties. The final stage of the reaction involved is preceded by a phenomenon which can best be indicated as comparable to that of gelling. A good mixture of this type will be more or less fluid immediately after preparation, but will solidify into a gelatinous mass in a predetermined time. At this stage it will be resistant against the attack of the sea or ordinary water.

This product was named "Eshalite D.V." and represented a big advance in sea defence technique, providing authorities and contractors with a cold mix system easily applied at a very cheap cost. It is offered for sale by the U.K. and Commonwealth concessionaires, Dussek Bitumen and Taroleum Ltd., in conjunction with Soil Engineering and Contracting Co. Ltd., agents in the United Kingdom for Messrs. Smid and Hollander.

After continued research it was found that Eshalite can be incorporated into a number of different mixes and each particular work problem can be given a reasonably simple specification.

Soil Engineering and Contracting Company Limited have recently carried out certain research work on a par with that carried out in Holland, and Eshalite D.V. has been used by the War Department at Shoeburyness and by other authorities for initial tests.

The following recommendations are made with regard to the constituents of Eshalite mixes.

Cement. While rapid hardening cement is necessary for use in mixes to be placed below water, or between normal high and low water marks, Portland cement may be used in situations not requiring rapid set. The type of cement used, quite apart from the quantity, has a definite bearing on the consistency of mix and speed of set; Ferrocrete, or similar rapid-hardening cement is, in general, to be preferred.

Sand. A medium coase sand is recommended for use with Eshalite. It need not be dry, but if damp, its moisture content must be estimated and taken into consideration in connection with any water added to a mix. Coarse sands tend to increase the set of the mixes, and mixing time must therefore be kept to a minimum. A finely graded sand will retard setting, and while this may not be of vital importance on work above high water marks, it is not recommended for work where a rapid set is required. It will be seen that any sand locally available may, with certain precautions, be used, from fine dune sand to coarse river sand. If damp, salt-laden sand from the sea-shore is employed, however, it is necessary to incorporate an additive to counter the effect of the salt on the setting properties of the mix.

[Courtesy of Lincolnshire River Board

Trial section of a sloping revetment at low tide showing in the foreground slag prior to grouting with Eshalite, and slag grouted. In the distance beyond the white line the slag has been grouted with hot applied bitumen/sand mix.

[Courtesy of Lincolnshire River Board

Trial section of slag revetment and stone blocks grouted with Eshalite being covered by an incoming tide immediately after pouring.

Aggregate. While an Eshalite/cement concrete mix can be made, incorporating 1¼-in.—¼-in. graded aggregate—preferably, but not necessarily, crushed stone—it is usually used for emergency filling with large blocks or stone. The batches are tipped and the large blocks are consequently bedded and surrounded. An Eshalite/cement concrete cannot, of course, he used for sealing small joints, an Eshalite/cement/sand/mortar being utilised for this class of work. Eshalite/cement concrete of ¾-in. down is also suitable for grouting random stone, and generally for laying below water, since its higher specific gravity allows it to fall through the water faster than a mortar, and because it will tend to have a higher resistance to disintegration in the water. Where it is desired to grout and cover hand-laid pitching on sloping aprons, a finer grading of aggregate can be used to make Eshalite/cement concrete, e.g. 5/16-in. o r½-in. down, and such a mix will have little tendency to flow on aprons even of fairly steep gradient. It must be emphasised that the gravel or sand must contain no silt.

Water. Where it is necessary to add water to the mix to obtain the required consistency in the mixer, clean fresh water should be used. If, however, only salt water is available it will be necessary, as with the use of salt laden sand, whether damp or dry, to incorporate a chemical additive.

Mixing. In cases where a rotating-drum batch type mixer is used, it is preferable first to introduce the Eshalite and any water necessary to give the desired consistency—ascertained previously by experiment—then the cement and sand or the cement, sand and aggregate. Water should under no circumstances be added after Eshalite and aggregate are in the mixer. As the time of mixing has a direct bearing on the consistency and the setting time of the mix, it should be quite brief and the time from loading the mixer to discharging it should not exceed 90 seconds.

When an open tilting-drum type of mixer is used, cement sand and aggregate can be premixed with any water required before adding Eshalite since this type of mixer invariably discharges completely. The rotating drum type does not always do so, and consequently unless Eshalite is put in first there is a tendency for a layer of incompletely mixed aggregate to build up in this type of mixer. As has already been mentioned, the time of initial set into a gelatinous mass, which will be resistant to sea or fresh water, can be controlled—a necessary feature if, for example, the mixer is not able to be taken close to the work site, which could be around low water mark on a sandy shore, the main plant being on the sea-wall above high water mark.

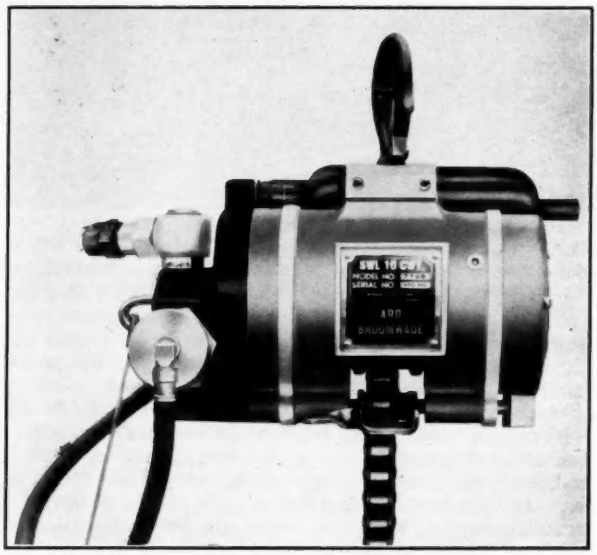
Spreading and Laying. The mixes can be poured direct from the mixer down chutes or pipes, from barrows or buckets, or by crane

(Concluded at foot of following page)

Manufacturers' Announcements

Lightweight Pneumatic Hoist

A pneumatic hoist which is claimed to be the lightest and smallest of its kind yet produced, taking into account its specified capacity and speed of lift, has been announced by Messrs. Broom and Wade Limited of High Wycombe. The machine is known as the Aro Broomwade Mini-Hoist, and is extremely compact, measuring only 10½ inches in length by 5 inches in diameter. It is supplied with either "Pull" or "Pendant" push button controls which actuate a throttle giving precision speed regulation from inching to the rated maximum. With the standard head fitted the hoist will lift 10 cwts. at 25 feet per minute.



The illustration shows the compact nature of the Mini-Hoist.

The vane type motor is totally enclosed and the exhaust noise is reduced to a minimum. The motor cannot burn out even if stalled indefinitely and is unaffected, in ordinary operation, by dirt, fumes or heat.

Special features included into the design of the hoist are:

(a) a mechanical brake with bonded lining;
(b) ball or needle-bearing mounting for all rotating or oscillating parts;
(c) ⅜-in. B.S.P. air inlet swivel with 180° swing;
(d) built-in oil reservoir

Top and bottom hooks of the hoist have a safety snap. An adjustable chain stop limits the lift or drop. The automatic brake locks when the power is shut off and the load stays up in the event of an airline failure but can be lowered safely and speedily by throttle control.

Rapid Setting Mixes—*continued*

in skips, depending on the situation. For grouting hand pitched or random stone, any of these methods may be employed. For placing the mixture below water a bottom-opening skip which opens on contact with the stone to be grouted, or the sea bed, is very satisfactory, or the mix may be poured down a chute or a pipe of suitable diameter, one end of which is placed beneath the mixer outlet and the other over the position to be grouted, moving it as required. This enables a more or less continuous flow of grout to be poured, since mixing time is of short duration. Above water level, on smooth surfaces, and for sealing close joints, the grout can be spread by broom. Where a canal, river or sea-wall is breached under storm or flood conditions and random stone can be tipped into it, a mixture can be poured below and above the water to seal it off. Much emergency work of this nature has been carried out in Holland.

Dredger for the Port of Calcutta

Messrs. Wm. Simons and Company Limited, Dredger Builders, of Renfrew, recently launched the Twin Screw, Drag Suction Hopper Dredger "Bhagirathi" which they have constructed to the order of The Commissioners for the Port of Calcutta.

This dredger, which is one of the most modern types yet built, has been designed for service on the River Hooghly, and in particular for working on the Eastern Gut Bar of the James and Mary Sand. This Bar varies in depth from 21 feet after the rains to 6 feet at the end of the dry weather season, and the object of the dredging is to maintain a navigable depth of 14 feet at L.W.O.S. tides.

The currents on the Bar are very strong and in spring tides are likely to reach 8 knots. The navigation of the Bar is confined almost entirely to the flood tide, and dredging must take place day and night on the ebb tides which run for about 8 hours. The dredger is intended to work under way, steaming into the tide and is required to work in the worst conditions in currents up to the 8 knots maximum.

The dimensions of the new vessel are:

Length b.p.	350-ft.
Breadth, moulded	62-ft.
Depth, moulded	24-ft.

The hopper capacity is 3,000 tons and the pumps provided will enable the vessel to fill her own hopper in about 40 minutes.

The dredging outfit consists of a set of triple expansion engines driving a 45-in. bore suction pump.

The vessel is fitted with two sets of triple expansion propelling engines and four steam marine cylindrical multitubular boilers arranged for burning oil fuel in forced draught. The speed of the vessel when fully loaded is 12 knots.

The "Bhagirathi" includes in her design and construction many improvements in detail suggested by the experience obtained in the actual working of the previous suction dredgers constructed by the builders for service at Calcutta.

Installation of New Dipper Dredge

An interesting conversion has been carried out on a dredge owned by the Oil City (Pennsylvania) Sand and Gravel Company, U.S.A. The existing bucket dredge operated by the company, was removed from its hull and in its place a new dipper dredge, manufactured by the Ellicott Machine Corporation of Baltimore, Maryland, was installed.

The new dredge is a diesel electric powered machine of 1½ cubic yards capacity. It is made up of four basic units comprising:

(a) A complete front assembly for a dipper.
(b) Hoisting equipment.
(c) An electrical DC generator.
(d) A control system for operation of the front assembly and another for the operation of the "pin-up" or spud equipment.

View of converted dredger.

Manufacturers' Announcements—*continued*

Certain other items, such as screening and washing plant, were salvaged from the old dredge and incorporated into the new installation.

The dredge is powered by Cummins diesel engines driving both an AC and DC generator. One generator is a 50-Kw. unit of 250 volts and 200 amps, used for operating the main hoist, and the other, a 10-Kw. unit, supplies power for the lateral movements.

An unusual feature of the power and control equipment is the Ward-Leonard system of excitation control for the DC motors of the main hoist and swinger. The Westinghouse air control valve on the crowd brake and a solenoid air control on the bucket trip are also features of interest.

All motions of the dredge are controlled by one man who manipulates the dredge hoist and trips the bucket with the right hand control; the left hand lever actuates the lateral movements; the crowd brake air controller is operated with the right foot and the drum controller on the back haul with the left foot. All these operations may be carried out from a sitting position.

As pin-up operations are performed less frequently, separate controls are provided for operating this equipment. The pin-up is used to steady the dredge and shift its position when a change of location is needed. Long moves are made with the help of a tug.

The new dredge is able to dig to a depth of 23 feet. Large rocks, which comprise a considerable part of the river-bed material in the working area, are lifted in the dipper, or shovel, and discarded into the river at another point. The dipper completes a digging operation every 70 seconds and is capable of maintaining the cycle of operations even in areas where the bottom is exceptionally hard. Its heavy weight gives a "crowding action" which forces it firmly into the formation to be raised. The 1½ cubic yard load from the dredge is dropped into a dump pan and flows through a grizzly, where large stones are separated and drop back into the river.

Rocks smaller than eight inches are carried on a 30-in. conveyor belt and whenever market demands warrant, material two inches and over in size is conveyed from a three-deck screen to a 10 x 36 inch jaw-type crusher. The product of the crusher is returned to the main screen and conveyed to a gravel barge on a 24-in. flat belt, while virgin sand is carried to a sand drag by means of a flume.

In the drag the sand is de-watered and moves to a sand barge on 18-in. herringbone type conveyor belts.

New Rail Crane

The latest and largest addition to the Coles range of cranes is a rail-mounted crane model R5010 "Samson." Designed, manufactured and marketed by Steels Engineering Products Ltd., Sunderland, England, this crane is able to lift 45 long tons (100,800 lb.) at a radius of 12 feet when fitted with a 50-ft. centres jib.

The standard jib is a strut type of lattice construction made in two sections, of combined total length 50 feet, which can be extended to 80 feet by the use of extension pieces. For cranes with twin hoisting drums a 25 feet fly-jib may be used as a straight extension or swan neck, with a maximum offset of 6 feet from the centre line of the main jib.

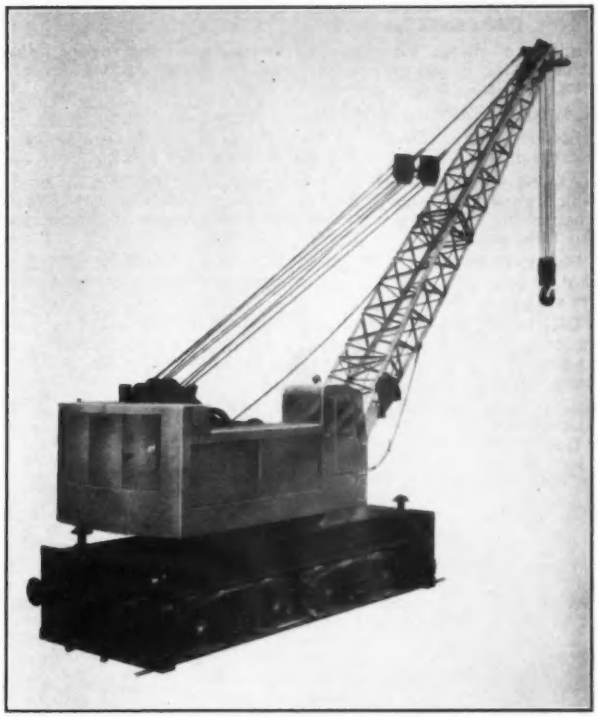
When fitted with standard jib, the R5010 weighs approximately 84 tons and has a shunting capacity of 400 tons when working on a straight level track.

When required, an electro-magnet of up to 50-in. diameter may be fitted and for grabbing duties an assortment of grabs are available with a maximum capacity of 45/36 cubic feet, a spring loaded tag-line being provided for extra control.

A radius indicator shows at a glance the safe working load for the jib radius and any tendency to overload is immediately corrected by a special safe load indicator, a fully automatic safety device with both visual and audible warning signals.

The Coles diesel-electric transmission system is featured on this new model, the power plant consisting of a 100 h.p. diesel prime mover driving a shunt-wound generator, which in turn supplies current to separate motors for each of the 4 crane motions of hoist, derrick, slew, and travel.

A great advantage of this transmission system is the resulting reduction in fuel consumption since the engine is not kept running at constant high speeds, power being developed according to need and used efficiently when required.



Coles model R5010 "Samson" rail-mounted crane.

Should the supply of current be interrupted either intentionally or accidently, automatic electro-mechanical brakes are immediately applied to the crane motions irrespective of any action on the part of the operator.

The operator's cab follows the pattern of other Coles cranes in having simple, conveniently grouped finger tip controls to give fatigue-free operation over prolonged periods. Control is effected by one lever for each motion which makes the electrical connection for both directions of any motion.

The chassis frame is mounted on 2 bogies, each with 4 single flange steel wheels and driven by 2 separate electric motors. A drawhook and chain is also fitted and other items of optional equipment on the chassis include derailing beams and rail clips.

The Ring Dolphin

In the July 1957 issue of this Journal, we published on page 110 a detailed description of the Ring Dolphin. This evoked a number of enquiries from abroad, and we have now been asked to announce that the Ring Dolphin has been patented in England and in other countries and is to be manufactured by the Redheugh Iron and Steel Company (1936) Ltd., in collaboration with the patentee.

It was recently announced that C. H. Dobbie, Consulting Engineer, has taken into partnership Col. R. C. Graham, Dr. Prus-Chacinski and Mr. W. B. Harris, the firm now being C. H. Dobbie and Partners. Col. R. C. Graham, O.B.E., recently retired after 33 years' service in the Royal Engineers. Dr. T. M. Prus-Chacinski, Ph.D., D.I.C., Dip.Ing., A.M.I.C.E., was a senior land drainage officer in Poland and became Assistant Professor and acting Head of the Civil Engineering Department of the Polish University attached to London University, who granted him a Ph.D. for his work in hydraulics. He joined his present firm in 1954. Mr. W. B. Barnes was articled to Major R. G. Clarke, served 6 years in the Royal Engineers and was on the staff of the Nene Catchment Board before joining the present firm in 1950.

APPOINTMENTS VACANT

NEW ZEALAND MINISTRY OF WORKS PROFESSIONAL AND TECHNICAL STAFF

The Ministry of Works, New Zealand, invites applications for the following vacancies on the Permanent Staff. Positions, qualifications desired and commencing salaries are as follows:

CIVIL ENGINEERING DIVISION.

1. ENGINEERS. Corporate Membership of the Institution of Civil Engineers, London. Commencing salaries from £895 to £1,465 per annum.

2. ASSISTANT ENGINEERS. A University degree in Civil Engineering which gives exemption from final Parts I and II of the A.M.I.C.E. examination or an equivalent examination. Commencing salaries from £810 to 1,000 per annum.

3. ENGINEERING ASSISTANTS. General Certificate of Education standard or equivalent, and eight years' practical experience. Commencing salaries £810 to £1,080 per annum.

4. DRAUGHTSMEN. Ordinary or Higher National Certificate or equivalent and at least three years' experience at the drawing board. Commencing salary up to £1,150 per annum in accordance with qualifications and experience.

Enquiries mentioning this paper and quoting reference No. 3/74/133, also stating type and number of position sought, should be addressed to the High Commissioner for New Zealand, 415 Strand, London, W.C.2. Full details of duties, experience desired, and general information on the conditions of employment in the New Zealand Public Service, together with application forms will then be furnished.

MANCHESTER SHIP CANAL COMPANY

The Manchester Ship Canal Company invite applications for the appointment of an Assistant Civil Engineer on the established staff of the Chief Engineer. Applicants should be between the ages of 25 and 30 years. The salary will be in accordance with age, qualifications and experience.
Candidates should be Corporate Members of the Institution of Civil Engineers or hold equivalent qualifications, and should have experience in design, specifications, construction and maintenance of civil engineering works. Harbour and dock experience is preferable but not essential.
Successful applicants will require to become members of the Company's Contributory Superannuation Scheme.
Applications, stating age, qualifications and experience should be addressed to the Chief Engineer, Manchester Ship Canal Company, Ship Canal House, King Street, Manchester, 2.

NIGERIAN PORTS AUTHORITY

NIGERIAN PORTS AUTHORITY, a recently created Public Corporation offering attractive prospects, have a vacancy for a Port Engineer.
Candidates must be between 35 and 45 years in age, Corporate Member of the Institution of Civil Engineers with experience preferably with a Port or Harbour Authority, construction and maintenance of docks and harbour works, building, permanent way and roads. Experience in electrical and mechanical appliances normally associated with port operating is most desirable. The work involved covers a wide field including administration and control of the staff under him.
The successful candidate will be directly responsible to the Chief Engineer for his section of the Engineering Department. He will be required, in the first instance, to serve at Port Harcourt where extensive new works are in hand by contract.
Salary in the range £1,750—£1,900 per annum, plus £300 per annum Overseas Pay. Point of entry dependent on age and experience. Qualification Pay of £75 per annum non-pensionable for suitably qualified persons.
Appointment for one tour in the first instance. Thereafter, subject to satisfactory service, employment will be on a permanent basis. Non-Contributory Pensions Fund. Tour normally 12—18 months.
Leave on basis of 7 days for every completed calendar month of service. Free First-class passages for officer and wife. Additional passages and allowances for children.
Furnished accommodation provided at a reasonable rental.
Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2B/42431/DU.

NIGERIAN PORTS AUTHORITY has vacancies for TRAFFIC OFFICER INSTRUCTORS. Men of matured experience aged 45 or above or with at least twenty years' practical experience in quay/shed work in a large scale port organisation.
Applicants must be of a keen and energetic disposition and have requisite capacity and temperament for training Nigerian Staff. Knowledge of all aspects of cargo handling essential including some years practical and supervisory experience in shed/quay work, customs and other documentary procedures and the use of mechanical handling equipment.
Successful candidates will be appointed on a contract basis for two or three tours. Salary will be £2,000 per annum consolidated with eligibility for a gratuity at the end of the period of service.
Tours normally 12—15 months. Leave on basis of seven days for every completed month of service. Free first-class passages for officer and wife. Additional passages and allowance for children. Furnished accommodation at reasonable rental. Car allowance and free medical attention. Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M3B/43712/DU.

BRITISH TRANSPORT WATERWAYS require an ENGINEERING ASSISTANT at Watford. Applicants must be Associate Members of the Institution of Civil Engineers and have had wide experience in design and construction of civil engineering works, both by contract and direct labour. Particular emphasis on hydraulics in connection with river and canal works and of structures in concrete, mass, reinforced, pre-stressed and steel. Experience in specification and Bills of Quantities is essential. Salary range £1,015—£1,235, superannuation fund and certain privilege travel facilities. Applications stating age, experience and qualifications to the Staff and Establishment Officer, 163, Euston Road, N.W.1, by October 22, 1957.

PORT EXECUTIVE OFFICER required by TRINIDAD Government to administer the Port Services Department on contract for one tour of three years in first instance. Salary, according to qualifications and experience, between £2,500 and £3,000 a year. Free passages. Liberal leave on full salary. Quarters provided at reasonable rental. Candidates must have administrative ability of a high order and considerable practical experience of port industry and administration. Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M3B/44242/DU.

D.S.I.R. requires Civil or Mechanical Engineers (Scientific Officer Grade), for hydraulic research, including work on models at Hydraulics Research Station, Wallingford, Berks. Quals. 1st or 2nd Class Hons. degree in appropriate subjects. Salary range, depending on age and experience: £595—£1,050 (men), £595—£974 (women) but Equal Pay Scheme. Five day week. Favourable housing prospects for married candidates. Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting Ref. E.74/7A. Closing date October 29, 1957.

DOCK AND HARBOUR ASSISTANT ENGINEER required by consulting engineers for design work in London. A.M.I.C.E. or equivalent. Experience on design and sites advantageous but former essential. Opportunity for subsequent site work abroad. Age range 28-35 preferred but emphasis more on experience than age. Permanency with staff pensions and salary to be related to qualifications and experience. Box No. 200, "The Dock and Harbour Authority," 19 Harcourt Street, London, W.1.

TENDERS

Port of Bristol Authority offer following vessels for sale "as lying" in Bristol Docks Area:

BUCKET DREDGER "B.D.2." Self propelled, tonnage 254 gross, 150 nett. Built 1896, length 117-ft., beam 27-ft., draft 9-ft. 6-in. Maximum dredging depth 32-ft., Dredging output 300 tons per hour. Able to cut own flotation.

STEAM HOPPERS "AVON 1" and "FROME 1." Length 166-ft., beam 27-ft. 6-in., draft 13-ft. Twin screw, Triple expansion engines. Hopper capacity 600 tons. Built 1900. The above hoppers were classed XA.I. in Lloyd's Register until, following the delivery of new plant, they were laid up.

Further particulars, conditions of sale, tender forms and permission to inspect from Chief Engineer.

Tenders by November 22 to Engineer-in-Chief, Port of Bristol Authority, Avonmouth Docks.

BOARD OF MANAGEMENT FOR THE PORT OF RANGOON

DEVELOPMENT OF RANGOON PORT. Civil Engineering Contract No. 2, Transit Sheds, Warehouses and Workshops.—The closing date for the above Contract is now 12 noon on Saturday, November 2, 1957, instead of September 28, 1957 (as previously notified in the issue of August, 1957).

WIN PE (Chairman).

COMMISSIONERS OF PUBLIC WORKS

Sealed tenders addressed to the Secretary, Office of Public Works, 51, St. Stephen's Green, Dublin, will be received up to, but not later than, 12 noon on October 31, 1957, for the purchase and removal of TWO McKIERNAN-TERRY 9.B.3. HAMMERS AND ROCK-BREAKING ATTACHMENTS, Very little used; may be inspected at Central Engineering Workshops, Inchicore, Dublin.
The Commissioners will not be bound to accept the highest or any tender.

J. TYRELL, Secretary.

FOR SALE OR HIRE

HUDSWELL CLARKE 0-6-0 STANDARD GAUGE STEAM LOCO, in good condition.—Apply, Eagre Construction Co. Ltd., Scunthorpe, Lincolnshire. Telephone: 4513 (7 lines).

WANTED

LIGHT CONSTRUCTION, DOCK CRANE. Capacity 5 tons at 30-ft. radius.—Box No. 199, "The Dock and Harbour Authority," 19, Harcourt Street, London, W.1.

Back Numbers of "The Dock and Harbour Authority."

1955 February; May; December.

1956 March; April; May; June; July.

If you have copies available, please write Box 197, "The Dock and Harbour Authority," 19, Harcourt Street, London, W.1.